The Electrical World.

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In the growth of the paper in circulation, size and general improvement, the value of its columns for reaching those engaged in electrical pursuits has not failed to be appreciated by advertisers. The following table shows its steady onward march in this department of business. The first issue of

1880	contained	25	different	adv'ts.	1887	contained	154	different	adv'ts.
1881	"	28	"	"	1888	"	175	"	"
1882	"	45	"	"	1889	"	234	"	"
1883	"	63	"	"	1890	"	289	"	"
1884	"	82	"	"	1891	"	325	"	"
1885	"	100	"	"	1892	"	316	"	"
1886	"	138	"	"	1893	"	317	"	"

The first issue of 1894 contained 320 different Advertisements.

No announcements of the Publisher are included in this list.

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ADVERTISING IN CONVENTION ISSUES.

The following comparison of the advertising in the convention issues of The Electrical World during the last four years shows—if this may be accepted as a criterion, as it probably can—that the popularity of the National Electric Light Association with business men continues unabated, and indicates the healthy condition of the electrical industry.

	Pages.	Number of advertisements.	Inches of advertising.
March 7, 1891	42	301	2,099
Feb. 27, 1892	52	357	2,613
March 4, 1893	56	378	2,828
March 3, 1894	76	386	3,215

Owing to the recent change of form the number of pages cannot be directly compared, the present page aggregating 44 inches of advertising space, against 56 in former years, but this does not, of course, apply to the number of advertisements, or to the number of inches of advertising. The present issue of The Electrical World is the largest number of an electrical journal that has ever been published.

REMOVAL OF THE ELECTRICAL WORLD'S OFFICES.

About April 1 The Electrical World will remove its publication offices to the new Postal Telegraph Building, 253 Broadway. This is directly across City Hall Park from its present quarters and adjoining the building in which it had its first offices, No. 9 Murray street. The Electrical World will occupy the entire Broadway front of the building on the third floor, and for its signs will have twelve different windows extending across the Broadway front and on Murray street. It is believed that this will be the pleasantest and most attractive home of any strictly technical journal published. The Electrical World was the first tenant to take rooms in the new "Times" Building, and will be one of the first to move into the just completed headquarters of the Postal Telegraph Company. This is the fourth building in New York in which the paper has had offices. In each it has occupied larger and more desirable quarters than before, and at higher rent. This is particularly true in the present instance, but considering the building and the location our friends will, we feel sure, say that the move is a judicious one, and be gratified to know that a journal devoted to electrical progress should find itself at the beginning of its twenty-first year in so commodious quarters, desirably located on such a prominent business thoroughfare.

ARC LAMP GLOBES.

In referring in these columns before to the subject of the loss of light from the use of arc lamp globes we expressed a hope that some experiments would be made to test the truth of the older data on the subject, which showed this loss to be very great with the kinds of globes in ordinary use. Elsewhere in our pages Prof. Shepardson gives the results of experiments made under his direction, which in some respects confirm the truth of the statement that this loss is indeed large. A mean spherical candle power of 319 from the bare arc we find is reduced to 235, 160 and 144 candle power when clear, ground glass or opal globes are used, which gives a loss of light of 26, 50 and 55 per cent., respectively. For interior illumination the loss from the use of ground glass and opals is somewhat compensated by the better distribution and quality of light, but for exterior lighting the waste is so great as to counterbalance in most cases the benefit arising from the employment of such globes. The complaint of the small power of the arcs on Fifth avenue of this city in the light of these figures is seen to have a real foundation, but this is one of the few special cases in exterior

lighting in which the sacrifice is perhaps justifiable. In lighting large interior spaces, where the quality of the light is an object, the use of opaque globes and a great part of the consequent loss of light involved may not only be avoided, but the quality of light also improved by the use of inverted arcs, which is a method of illumination that should be more often applied than it has been in the past.

TWENTY YEARS OF ELECTRICAL PROGRESS.

The story told in another column of the triumphant march of the electrical industries during the last two decades has no parallel in the history of material progress, and marks a period that will always add lustre to the nineteenth century. While some grand fundamental discovery may give rise to another similar period, the electrical age, like the Augustan age and the few other remarkable periods in the history of the world, will nevertheless always stand out prominently and be one of the glories of a century otherwise so richly endowed. Those who have taken part in the work that has produced such magnificent results will feel a pleasure in reviewing the various steps with the competent writers who recount them elsewhere, while to the younger aspirants to electrical honors the recital will possess a direct value, and perhaps awaken in some a determination that their names shall eventually be added to the list of those who will receive mention by future writers of electrical history.

THE WASHINGTON CONVENTION.

The meetings of the National Electric Light Association have long occupied a prominent place in the electrical field and have been looked forward to for months in advance with great interest. The fact that they now occur but once a year, the Washington meeting being the second under the new regime, tends to emphasize their importance and give additional assurance of success. The seventeenth meeting of the association, which occurs this week at Washington, promises to prove a dangerous rival to its predecessors. From present indications, the attendance will be considerably in excess of that of any previous meeting, an unusually large delegation going from New York City and vicinity. The officers of the association have been untiring in their efforts to render the arrangements perfect and to provide an attractive programme. In addition to several important papers, a large number of topics for discussion are announced, which is likely to prove an important feature of the meeting and bring out facts of interest and value. Among other questions of timely interest that will receive consideration are the proper rating of arc lamps, the most economical size of arc dynamos, and meters vs. flat rates. The paper on "Polyphase Transmission," by Mr. Charles F. Scott, and the discussion of Mr. Tesla on "Alternating Current Motors" will doubtless attract considerable attention.

INSTITUTE POLITICS.

While the friends of the American Institute of Electrical Engineers will be pleased, and many, under the circumstances, doubtless astonished, at the argument made at the last meeting in favor of the position that legislation affecting the institute should only be considered at the annual meetings, they will at the same time, we think, be disappointed at the fate of the measure designed to prevent a repetition of last year's inexcusable manipulation of election machinery. While we have earnestly advocated the relegation of all legislation to the annual meetings, we would have gladly had the recent practice continue until the rule referred to was adopted, and scarcely expected that the inception of what was looked forward to as so desirable should defeat what was considered of even greater importance. As the secretary stated, however, the amendment of the election rules would have had no effect on the coming election, though, it may be remarked, this was due to deferring action upon it when introduced. We trust that the matter will now be brought before the annual meeting, as well as a definite measure making illegal any legislation at other than the general meetings of the institute. The action of President Houston in appointing an honorary secretary for the Chicago local meeting inaugurates the principle for which those in sympathy with the reasonable demand of members not resident in New York and vicinity have contended, and will, we feel sure, meet with general approval. If now the annual meeting fixes the ruling referred to, that the New York meeting cannot legislate, which is equivalent to placing it on the same basis as the Chicago or any other local meeting, as it should be, and takes the proper measures for preserving the purity of the ballot, the institute will be placed on a basis that all of its real friends, among which we include ourselves, have hopefully looked forward to—an action which also, we trust, will put an end to Institute politics.

ENGINEERING DICTA.

In every branch of engineering there seems to be an element which, upon the appearance of a new discovery or invention that attracts general attention, proceeds to make what capital it can out of the occasion by "pointing out" limitations, which frequently have the merest shadow of an existence, but nevertheless serve the desired purpose of connecting the name of the objector to the subject and give him an ephemeral reputation for deep wisdom. In the early days of electric lighting, for example, a then well-known author called the attention of the electrical public to the so-called fact that the law of maximum efficiency also applied to dynamos and other electrical apparatus, and that as a consequence to attain that efficiency, the internal resistance of the apparatus should be made equal to that of the exterior circuit—a dictum that for a time was dubbed a law with the author's name prefixed. Again, but extending to a more recent date, there was considerable discussion as to the relative requirements of incandescent machines to be run in parallel, and it was maintained by some and believed by many for some time that it was necessary that such machines should possess identical characteristics to be thus successfully operated—which conclusion practice has shown to be unwarranted. In another column Mr. Steinmetz successfully attacks other hypotheses built up by mathematical writers, that certain specific conditions are absolutely necessary for running alternators in parallel. By actual tests under the most extreme conditions he conclusively proves that we may discard all the usual theoretical statements on parallel working relating to the effect of frequency and self-induction and the use of artificial loads. The experiments showed that machines properly designed for the highest or the lowest frequencies work equally well when respectively coupled in parallel and that the self-induction of well designed alternators has nothing to do with their successful running in parallel—a statement that demolishes several cherished mathematical theories, as does the one denying the theoretical conclusion that the condition of best synchronous running is with a lag of 45 degrees. As an examination of the experiments made will show, the conclusion is amply sustained that with properly designed alternators parallel running is perfectly feasible, and that even under extreme conditions of load and excitation, no special or careful adjustment is required to throw two machines run at the same frequency in parallel.

CENTRAL STATION BOILERS.

Prof. Fessenden elsewhere discusses the subject of boilers for central and power stations and describes a remarkable boiler which has lately been attracting the attention of the

steam engineering profession. A boiler somewhat similar was designed some years ago by the Herreshoffs and exclusively used for torpedo boats and launches, but has, we believe, been discarded. The great difficulty with boilers designed with a small water capacity is the extreme attention they demand in operation, and the serious and immediate results from any neglect. Torpedo boat boilers, which are all of this type, require a supervision and an intelligence in the firemen that would be very expensive adjuncts to a steam plant ashore. In addition, the exhaustive strain on those operating such boilers through the strict attention required, while not impracticable with the short watches and intermittent steaming of torpedo boats, would be quite a different thing in continuous work. Nevertheless, much in regard to boilers may be learned from marine practice, and there are special boilers now in use on ocean vessels, and particularly on men-of-war, whose adoption ashore would be perfectly feasible, and at the same time beneficial. The remarks of Mr. Fessenden on artificial draft are very suggestive. The neglect of keeping in mind the distinction between forced and artificial draft through the extreme wastefulness of the former and its injury to boilers has resulted, in keeping the subject of the latter in the background. It is probable, however, that in time the use of blowers worked at a low pressure—normally less than a half-inch of water—will largely supersede the building of high chimneys, particularly where the demands for power fluctuate during different periods. The Howden system of low-pressure artificial draft, in which the air is heated in the uptake before going to the furnaces, has given excellent results in ocean work and points out the line to be followed. The subject of artificial and liquid fuel will also before long doubtless become one of importance, as is foreshadowed by an announcement made a few days ago that a vessel in the transatlantic trade had adopted the use of petroleum fuel with a fair prospect of attaining an economy over the use of coal. Aside from any question of superior economy of the fuel itself is that of the considerable saving that would undoubtedly result from the almost ideal manner in which such fuels can be supplied to the furnaces, thus saving the great wastes that result from the manner in which coal is fed and burned, and at the same time reducing the labor bill. The land steam engine was at least twenty years behind marine practice until the demands of the younger men connected with electrical engineering advanced it in a comparatively few years to its present state, and when the same element bestows similar attention to the boiler-room we may expect a proportionate change in practice there.

The Meeting of the American Institute of Electrical Engineers.

The eighty-fourth meeting of the American Institute of Electrical Engineers was held Wednesday evening, Feb. 21, at headquarters, 12 West Thirty-first street, with President Houston in the chair.

The papers of the evening were "Concerning a Change of Policy in the Administration of the Patent Office," by Mr. Philip Mauro, and "How Shall We Operate an Electric Railway Extending One Hundred Miles from the Power Station?" by Mr. H. Ward Leonard. Mr. Mauro's paper was read first, contrary to the published programme, in order to give Mr. Leonard a better opportunity to display his apparatus. Mr. Mauro's paper excited considerable interest, as it touched upon the question of curtailing the privileges of inventors. Written discussions from Mr. Vansize and Mr. E. P. Thompson were read by the secretary and verbal comments were made by Messrs. Olan, Forney, Sachs and Houston.

Mr. Leonard's paper was the attraction of the evening, and was thoroughly discussed by Messrs. Curtis, Mailloux, Perry, Hill, Hewitt, Kennelly, Field, Woodbury, Sachs and others. After reading his paper, Mr. Leonard exhibited a working model of his system installed upon the platform, and gave a practical illustration of its operation.

After the discussion, the report of the committee on revision of rules came up for action. It was moved and seconded that it be adopted, but Mr. Phelps objected, on the ground that there had already been adverse comment concerning the enactment of legislation by the monthly meetings, and a member moved that the report be laid on the table, but the motion was not seconded. Mr. Upton, in behalf of the committee, begged that some action be taken in the matter, as the proposed amendments in no way altered the spirit of the rule, but on the contrary rendered its original meaning clear and removed ambiguity therefrom. Mr. Phelps, however, insisted on his point, saying that much as he appreciated the need of the proposed amendments, he feared that the action of the meeting in adopting them would be adversely criticised, and considered it better to let the report stand until the annual meeting. The secretary then asked for information regarding the effect of adopting the report with regard to the coming election, and it was ruled that the election notices having been already sent out, the amendments, if adopted, could not take effect until the 1895 election. The motion to adopt was then withdrawn, and the motion to lay on the table was seconded and carried. Mr. Kennelly gave notice that the report of the committee on units and standards would be called up from the table at the March meeting.

Mr. Edward Caldwell was appointed honorary local secretary for Chicago, the requisite number of signatures having been obtained.

Moonlight Tables for April, 1894.

Herewith we give Mr. H. W. Frund's tables of lighting hours for the month of April under his modified form of moonlight schedule.

TABLE NO. 1.
Standard Moonlight System.

Date.	Light.	Date.	Exting.
1	5.50 P. M.	2	4.40 A. M.
2	7.00 "	3	4.40 "
3	7.00 "	4	4.40 "
4	7.00 "	5	4.40 "
5	7.00 "	6	4.40 "
6	7.00 "	7	4.30 "
7	7.00 "	8	4.30 "
8	7.00 "	9	4.30 "
9	7.00 "	10	4.30 "
10	11.10 "	11	4.30 "
11			
12	12.10 A. M.	12	4.30 A. M.
13	1.10 "	13	4.20 "
14	1.50 "	14	4.20 "
15	2.20 "	15	4.20 "
16	2.50 "	16	4.20 "
17	3.10 "	17	4.20 "
18	No Light.	18	No Light.
19	"	19	"
20	7.10 P. M.	20	8.40 P. M.
21	7.10 "	21	9.50 "
22	7.20 "	22	10.50 "
23	7.20 "	23	11.50 "
24	7.20 "	25	12.50 A. M.
25	7.20 "	26	1.40 "
26	7.20 "	27	2.30 "
27	7.20 "	28	2.50 "
28	7.20 "	29	3.20 "
29	7.20 "	30	3.40 "
30	7.20 "	1	4.00 "

Total hours, 170.10.

TABLE NO. 2.
Frund's New Moonlight System.

Date.	Light.	Date.	Exting.
1	6.50 P. M.	2	4.40 A.M.
2	7.00 "	3	4.40 "
3	7.00 "	4	4.40 "
4	7.00 "	5	4.40 "
5	7.00 "	6	4.40 "
6	7.00 "	7	4.30 "
7	7.00 "	8	4.30 "
8	17.00 "	9	4.30 "
9	7.00 "	10	4.30 "
10	7.00 "	11	4.30 "
11	7.00 "	12	4.30 "
12	7.10 P. M.	12	12 M.
13	1.10 A. M.	13	4.20 A. M.
13	7.10 P. M.	13	12 M.
14	1.50 A. M.	14	4.20 A. M.
14	7.10 P. M.	14	12 M.
15	2.20 A. M.	15	4.20 A. M
15	7.10 P. M.	15	12 M.
16	7.10 "	16	12 "
17	7.10 "	17	12 "
18	7.10 "	18	12 "
19	7.10 "	19	12 "
20	7.10 "	20	12 "
21	7.10 "	21	12 "
22	7.20 "	22	12 "
23	7.20 "	23	12 "
24	7.20 "	25	12.50 A. M.
25	7.20 "	26	1.40 "
26	7.20 "	27	2.30 "
27	7.20 "	28	2.50 "
28	7.20 "	29	3.20 "
29	7.20 "	30	3.40 "
30	7.20 "	1	4.00 "

Total hours, 215.40.

Note.—These schedules are made up on sun time. Where standard time is used and it varies considerably from sun time, the proper deduction or addition must be made to all the times here given.

Alternate Current Working.—III.

BY HARRIS J. RYAN.

The relation between alternating magnetism and the E. M. F. that it produces for a given current was found to be

$$B_{max.} = \frac{E \times 10^8}{1.4\ \pi\ a \sim l},$$

or

$$E = 1.4\ \pi \sim l\ a\ B_{max.} \times 10^{-8}.$$

Many cases occur in practice where the magnetism established is proportional to the magnetizing force, and, therefore, to the current in the electric circuit that is active in producing magnetism about itself. For many purposes under these circumstances it is usual to make use of the coefficient of induction. This coefficient of induction is the constant with which the magnetizing current must be multiplied, so that the product will equal the turns in the circuit multiplied by the magnetic flux. Its symbol is L, and its practical unit is called the henry.

$$C\ L = l\ M \times 10^{-8},$$

or

$$1.4\ C\ L = l\ a\ B_{max.} \times 10^{-8}.$$

Substituting this value for $l\ a\ B_{max.} \times 10^{-8}$ in the above equation, we have

$$E = 2\ \pi \sim C\ L.$$

In making this substitution the product of 1.4 into 1.4 equals 1.96 was taken as 2. This is customary and is sufficiently accurate for practical purposes, because of the uncertainty of the precise form of the alternating E. M. Fs., or currents. Again it is used to write $\omega = 2\ \pi \sim$, for this value is constant for any particular periodicity. This brings us to the form in which the relation between the E. M. F. current and coefficient of induction for a particular periodicity is usually written

$$E = \omega\ C\ L.$$

When the fall of potential produced by the ohmic resistance of a circuit is small compared to the pressure produced by the induction caused by the alternating current, the former may be neglected. Under such circumstances L for any circuit is determined by passing an alternating current of known periodicity through the circuit, the current and pressure that it produces are observed from an ammeter and voltmeter, and the values obtained are substituted in the above expression when L becomes known. L being known for such a circuit, the current that will be set up at any given

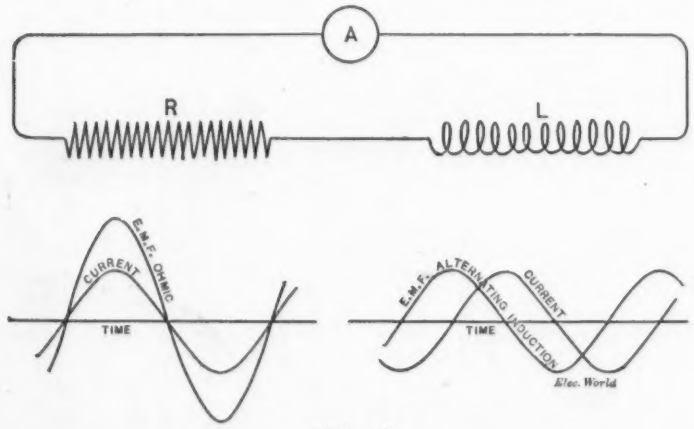


FIG. 10.

pressure is easily estimated. For example, in the circuit given in Fig. 10, $R = 0$, and L has a value of .1, while the alternator at A furnishes current at a periodicity of 125. What pressure will the alternator have to furnish to set up a current of 10 amperes?

$$\omega = 2\ \pi \sim = 2\ \pi\ 125 = 790.$$

$$E = \omega\ C\ L = 790 \times 10 \times .1 = 790 \text{ volts.}$$

Many conditions have to be considered, however, where the ohmic resistance of the circuit cannot be neglected. In all such cases we need to know how to determine the resultant E. M. F. that compensates for fall of potential, due to ohmic resistance and the pressure produced by the alternating induction. The same current is the cause of both these pressures, and though they are in series, they can only be added by determining the value of the sum of their instantaneous values. Fig. 10 illustrates a circuit in which we have a source of alternating pressure at A that establishes current through the circuit $R\ L$. R is non-inductive and possesses ohmic resistance, L is inductive and possesses no appreciable ohmic resistance. The magnitudes of R in ohms and L in henrys may in practice be any values. For the purposes of illustration in this case, we will assume that the fall of potential around R is double the pressure developed by the induction in L, as caused by the current that is common to both. The current and the E. M. Fs. that compensate for the fall of potential and induction pressure must be furnished by the alternator. They are plotted in their corresponding positions below R and L.

We have seen through earlier considerations that the E. M. F. that sets up current through a non-inductive resistance is in unison with the current, and the E. M. F. that establishes current against the pressure due to alternating magnetism is one-quarter period in advance of the magnetism, and, therefore, one-quarter period in advance of the current that establishes the magnetism or causes the induc-

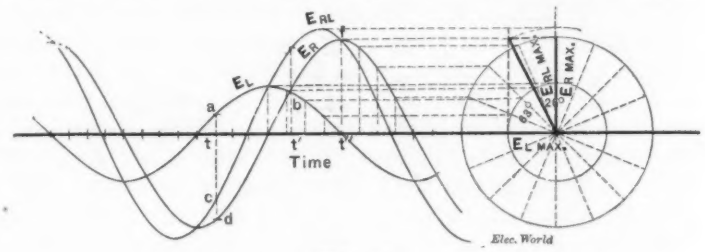
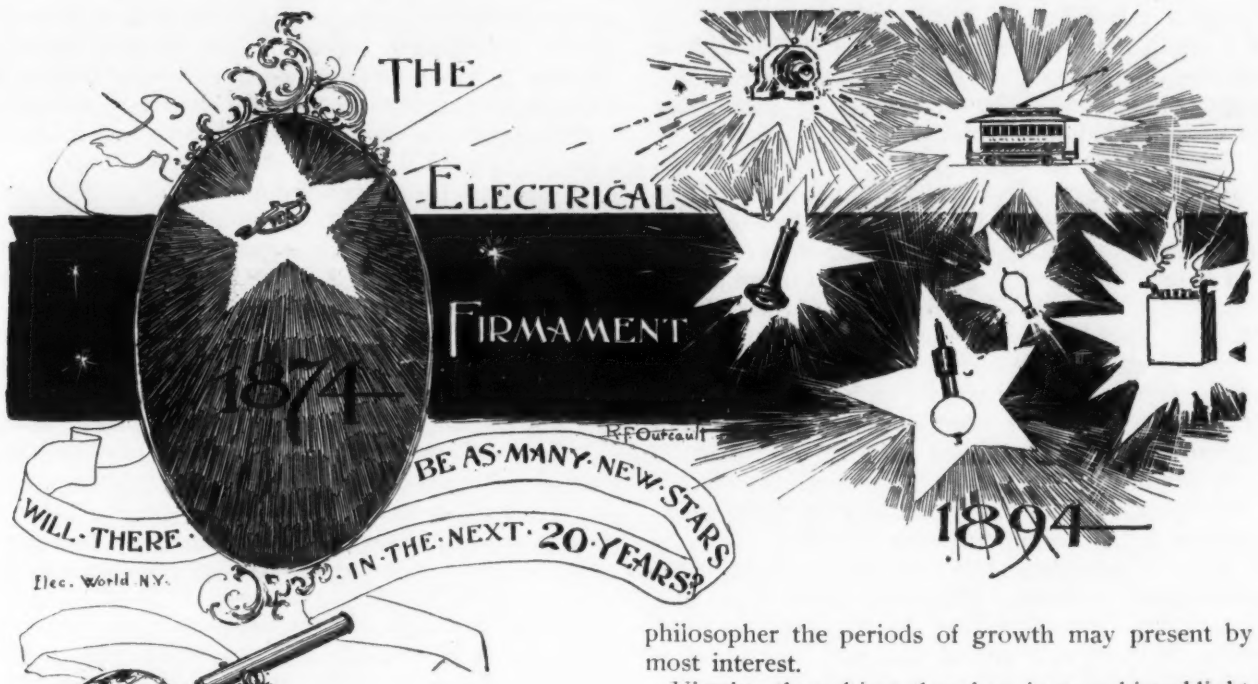


FIG. 11.

tion. In Fig. 11 these E. M. Fs. are plotted in such a manner that the induction E. M. F. E_L is one-quarter period in advance of the ohmic resistance E. M. F. E_R. A few of the construction lines are given for the purpose of showing a convenient method for drawing curves of sines. One circle is used for each of the curves E_L and E_R. The radius in each case equals the maximum value of the curve to be laid down, according to the chosen scale. The circle is then divided into as many equal parts as the number of divisions that have been chosen for the complete period. We then have one radius for each ordinate that is to be determined for the purpose of tracing in the curve. The vertical projections of these radii are sine values and determine the length of the corresponding ordinates of the curve, as is indicated by the broken construction lines. Positive rotation of the position of the radius whose vertical projection develops a curve of sines is anti-clockwise. Accordingly, since the fall of potential curve is one-quarter period behind the E. M. F. curve of alternating induction, the radius that develops E_R is at all times 90° behind, or a quarter of a period in a clockwise direction from the radius that develops E_L. When the E_R radius is vertical, its vertical projection is a maximum, and E_R is, therefore, maximum; at this time the E_L radius is horizontal, its vertical projection is o, and the value of E_L is, therefore, o. When the curves E_R and E_L are thus located graphically in their proper time relation, the resultant of E_R and E_L is the E. M. F. curve formed by the sum of their individual values at any instant. The curve whose ordinates are equal to the sum of the ordinates of E_R and E_L is determined by adding the ordinates graphically.

(To be continued.)



ALL doubtless remember the story of the two crusaders who disputed as to the material of a shield, one upholding with his life that its surface was of gold and the other no less fatally maintaining that it was of silver, both finding, however, when too late, that one side was of silver and the other of gold. With pens for weapons the same combat is constantly being repeated in the intellectual arena, every question presenting different views to different minds, many of them having distinct and apparently opposing practical and theoretical aspects that lend weight to either side of the argument.

For example, the assertions that, as compared with the first half of the century, electrical knowledge has made immense strides during the last twenty years, or that, in the same period, its progress has been slow, can both be maintained, if in the latter case the discovery of grand underlying principles is the criterion kept in view, or in the former the application of electrical science to the needs of man. For it is true that aside from the discovery of the electrical transmission of speech (if the friends of Philipp Reis will permit us this exception) no purely fundamental discovery can be claimed for the period under consideration. On the other hand, with the exception of the telegraph—and if we add a few years more this branch will then also be largely included—almost every application of electricity worth noting has had its birth or development in these two decades; and it does not require the gift of prophecy to predict that even thousands of years hence the last quarter of this century will stand out in the annals of progress as the age of Pericles does now in the records of antiquity.

While thus both of these two partisan views contain truth, yet each is the complement of the other, and we should no more sneer at the barren, practical record of the former period than accord a too transcendent importance to the later one. Without Faradays electricity might yet be in swaddling clothes, and without the practical spirit of our age it might still remain but little more than a plaything for the curious. The development of a science differs but in kind from an organic development; each period is necessary to the succeeding one, and while from a materialistic point of view the mature stage may be the important one, to the biologist or philosopher the periods of growth may present by far the most interest.

Viewing the subject, therefore, in an unbiased light, we may say that the period under consideration commenced with a generous endowment of material, crude, perhaps, incomplete in many instances, and with little promise in others, but from which have largely been developed the magnificent accomplishments which are detailed elsewhere in this issue of The Electrical World by writers of whom some have been recognized leaders in the great march of progress they describe, in which all have borne a part that gives authority to their views.

If an investigator had no other method at his disposal to determine the extent of growth during the last twenty years than the catalogue of an electrical library, he would have sufficient for his purpose. In a catalogue of almost four hundred electrical books before us, scarcely a score can be assigned a date as early as 1874, and the greater part have been published during the last eight years. While it is true that the great works of Faraday, Thomson and Maxwell were at that time printed and have not since been rivalled, yet the former then contained only a message for the initiated few, and the two mathematical works had a circle of readers still more restricted. Only in later years, when each new advance gradually revealed the profound scope of Faraday's thought, and other works furnished stepping stones to the heights of Maxwell, and when the experiments of Hertz had revealed the meaning of his wisdom—only then did they become to be understood. Aside then from these works and some on telegraphic science, electrical literature may therefore be said to have had its entire growth within the period considered. What the dearth of electrical books meant, even fifteen years ago, will be appreciated by those who then labored unassisted, even though under professorial instruction, with Jenkin, or one of its few contemporaries among text-books, and who also will recall the gratitude felt toward Gordon, Niaudet, Hospitalier, S. P. Thompson and other pioneers when their works appeared to assist them in the study of a science then bristling with difficulties and mysteries. Now all but the very newest branches of electrical science are elucidated in all of their details by an ever increasing army of authors, and the student also amply prepared beforehand for every probable development.

The subject from a technical standpoint is so fully covered by the articles which follow, that it is needless to further refer to technical progress here. As intimated before, the theoretical advances have been rather in the line of interpreting and extending the work of masters, but few of whom—though Maxwell and Thomson are of the number—lived

within the period considered. Those, however, whose labors have come within the era deserve none the less credit, for any lack of new discoveries must be ascribed rather to a lack of the opportunities so largely harvested by the earlier reapers than to lack of ability, as the work within the lines to which they were restricted have shown. Of these, Hertz, so lately with us in the prime of his intellectual life, was perhaps the greatest, and one whose experimental demonstration of the theories that Maxwell founded on the great conceptions of Faraday will always give additional lustre to our epoch. Rowland's researches in magnetism, his pre-Hertzian proof of the electromagnetic theory of light and other original work in electrical science, Ferraris' and Tesla's independent discovery of the rotary field, Joubert's discovery of the form of the alternating current curve, Hopkinson's theories upon which the design of electrical machinery is now based, Pupin's researches in resonance, Steinmetz's work in hysteresis, and the mathematical writings of Poincare, Heaviside, J. J. Thomson and Gray—these are some of the additions to knowledge that have been made, and the list might be extended by mention of further contributions in a more practical field by Elihu Thomson, Kennelly, Ewing, S. P. Thompson, Ayrton, Fleming, Duncan, Shallenberger, Kapp, Kelly and some others.

Of periodical literature we can speak with authority, for with this number The Electrical World enters upon its twenty-first year, the first number of The Operator, of which it is the direct successor, having been issued March 1, 1874. On this occasion we may perhaps be permitted to say a few words about our own career, offering as an excuse, if one be necessary, that its course almost exactly reflects that of the electrical industries in general. Beginning in an humble way with "P. O. Box 3,332" as an office and the use of a desk at the printer's, the first permanent quarters of the journal consisted of a single room, well up toward the roof, at No. 9 Murray street. Increasing prosperity had at first a depressing tendency as far as location was concerned, and finally the needs of expanding business and circulation and the ambitions naturally thus inspired, led to a search for larger quarters, which were found in the Potter Building, at a rental, it may be added, of more than three times that paid in Murray street. The next removal was to still more commodious and high priced offices in the "Times" Building. Neither excursion had gone beyond the immediate vicinity of the modest building in which the foundation of prosperity was laid, there being a seeming reluctance to lose sight of that landmark, and it may be that this is the determining cause for the next removal. For about April 1 The Electrical World will transfer its abode to the new Postal Telegraph Building at the corner of Broadway and Murray street, adjoining its original quarters, where it will occupy the most spacious as well as the most expensive offices of any purely technical journal in the world.

For the first seven of the twenty years to date it may be said that The Operator alone sufficed for the electrical public; what competition existed was merely ephemeral, the only permanent contemporary being the official organ of the Western Union Telegraph Company. Glancing through the slim files of The Operator and the progressively portly ones of The Electrical World (which name was assumed in 1883), we can trace every development of the period under consideration, while the rate of progress may be almost exactly measured by the growth of this pioneer journal. With but eight to ten small pages of reading matter and but two to four pages of advertisements in the first years, and but little other than telegraphic information in its columns, we gradually see the number of items and articles on the advance of other branches of electrical science increase. Shortly after the discovery of telephony, we are not surprised to see the change from a semi-monthly to a weekly, an increase both in reading and advertising pages, and the gradual appearance of cuts to assist in the explanation of the discoveries, then so singular to readers, which had begun to be made. Finally, with the first number of 1883, coincident with the change to the present name, we are made fully conscious of the strength which the electrical industry had begun to develop.

Perhaps no better measure of this growth from an industrial standpoint can ever be attained than that given by a survey of the advertising columns of The Electrical World. With but 63 advertisers in January, 1883, we find this number more than doubled three years later (138), and almost quadrupled in another three years (234); in 1891 the number reached 325, and the record since points to that year as the end of what we may call the period of electrical "promotion" and the beginning of an era based upon more stable business methods—an era that will probably be definitely fixed by the expiration of the great electrical patents.

A Review of the Progress of Telegraphy During the Past Quarter of a Century.

BY WM. MAVER, JR.

IT would be useless to claim that electrical telegraphy has made as rapid advances within the past twenty or twenty-five years as some of its sister branches, in view of the fact that several of the latter which are now in extensive successful operation were practically unknown for a long time after electrical telegraphy had reached maturity. For instance, arc and incandescent electric lighting, telephony and electric railroading, all of which, within a considerably briefer time than that mentioned have made such wonderfully rapid forward strides as to fairly entitle their progress to be classed as marvellous, even although occurring in an era which has been not inaptly termed the electric age.

But while it will not be claimed that electrical telegraphy has made in recent years as remarkable progress, whether considered from the scientific or commercial standpoint, as has been made in some other departments of applied electricity, yet should any one, distracted perhaps by the whirring of the more rapidly moving machinery of those sister pursuits, imagine that electrical telegraphy has been at a standstill for the past quarter of a century, or even for the last ten or fifteen years, such an one would, it may safely be asserted, find upon investigation that this has not by any means been the case.

A brief retrospect of the art of electrical telegraphy as it then was and a consideration of it as it exists to-day will, it is thought, confirm this assertion.

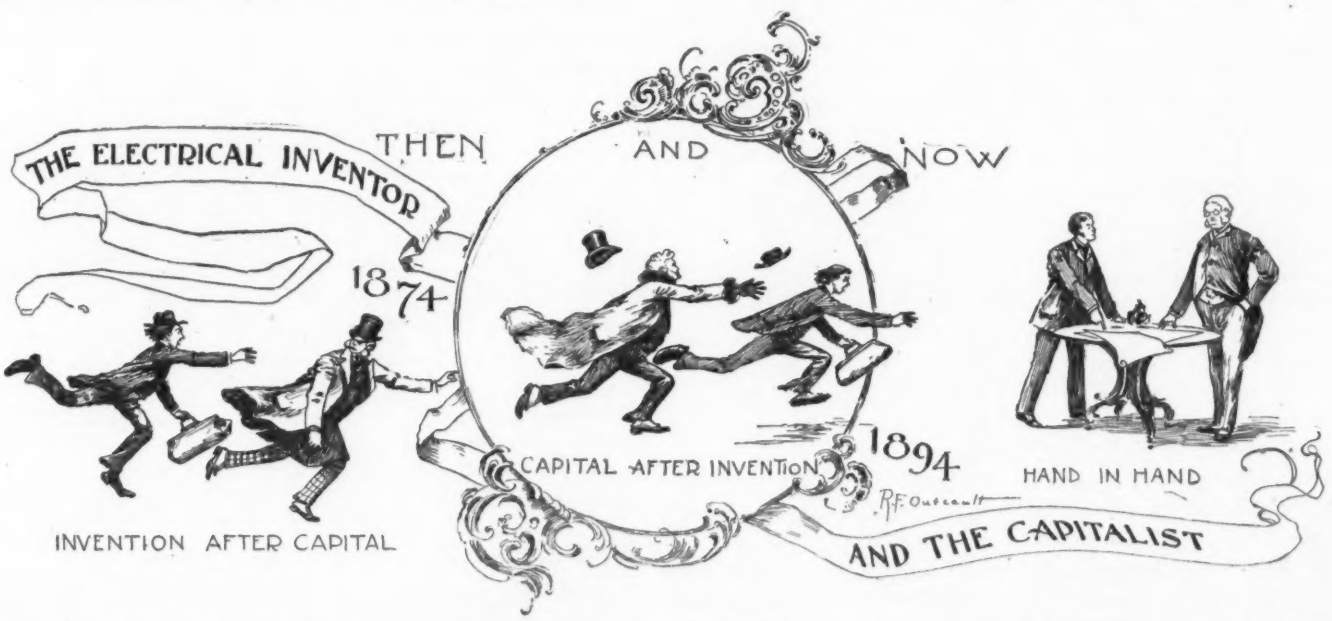
Twenty-five years ago the only systems of telegraphy in vogue in this country were the Morse telegraph system, the House and the Phelps printing telegraph systems, and some not very successful chemical automatic telegraph systems.

The speed at which messages were transmitted at that time by the Morse and printing telegraph systems was from 20 to 40 words per minute on land lines, and these figures represented the full capacity of a telegraph wire when those systems were employed. In Europe the systems most in use were the needle and dial telegraph systems and the Wheatstone automatic system, the speed of signals transmitted by the latter being about 80 or 100 words per minute.

Then, also, the Atlantic cable was, it may be said, in its infancy, and a speed of from 10 to 12 words per minute was the maximum rate of transmission by that cable. At that time the duplex system of telegraphy was scarcely known, except among telegraph experts—indeed, it was unknown as a successful practical method of telegraphing—and men of eminence in the profession alluded to it as a pretty scientific

toy, and as something that was likely to remain such. One author wrote: "Systems of telegraphy designed to transmit more than one message at a time must be looked upon as little more than feats in intellectual gymnastics, very beautiful in their way, but quite useless in a practical point of view."

Since then the Phelps and other printing telegraph systems have been constantly improved, until now they are capable of performing excellent work at the rate of from 50 to 60 words per minute. The duplex has long since ceased to be a scientific plaything and has been put to the most practical kind of service, and from it has been evolved the wonderful quadruplex system, by means of which four messages may be sent simultaneously over the same wire, on circuits from 100 to 600 miles in length, and at a rate of speed about equal to that at which one message is transmitted on a single Morse wire. The Wheatstone automatic telegraph has developed into a system by which from 400 to 600 words per minute can be transmitted over one wire, and this system is now in extensive use in this country and Europe. The Atlantic cables have all been successfully duplexed, so that now each cable may be said to have a capacity of at least 40 words per minute. More recently the Delany synchronous multiplex system has been perfected and is giving successful



results in Great Britain, where, by its aid, six messages are transmitted over one wire at one time in either direction. This system, it may be remarked in passing, was tried quite thoroughly in this country, but was not found to give the satisfactory results reported from Great Britain. This is probably due to the more humid atmosphere of that country; the system, when tried here, having been found to operate more satisfactorily during rainy weather than during dry weather. Presumably, also, the system may have been modified and improved on the other side.

Other systems of telegraphy have also been developed within the past few years, such as that one whereby it is possible to communicate to and from moving trains. The system by which simultaneous telegraphing and telephoning over one wire has been made possible has also been introduced within the past dozen years. Various new systems and improvements on the older systems of fire-alarm telegraphy, burglar-alarm telegraphy, etc., have also been brought out during the time mentioned, and, generally speaking, a marked improvement in the manufacture of telegraph apparatus has also been quite noticeable. It is not, however, only with the improvement of apparatus and with the invention of new systems of telegraphy that telegraph engineers have been occupied. For example, in 1880 the dynamo machine was utilized as a source of supply of current for the New York offices of the Western Union Telegraph Company, and its use in that capacity has been constantly spreading since that time. The importance of this use of the dynamo machine can scarcely be overestimated, its importance not alone consisting in the economy of maintenance of the dynamo machine, as compared with the chemical batteries formerly employed, but also in the economy of room space when space is very valuable. It is calculated that to supply the current now furnished by 10 or 12 dynamo machines in the New York main office of the Western Union Telegraph Company, about 50,000 gravity cells would be necessary, a quantity which could scarcely have been contained in two of the floors of that large building.

Much also has been done in the way of improvement in the practical operation of the telegraph by superior construction and insulation of the lines and in the employment of wires of better conductivity, such as larger iron wire, but more especially of hard drawn copper wire, the use of which latter, in telegraphy, was begun by the Baltimore and Ohio Telegraph Company in 1884, and has since been continued very extensively by the chief telegraph companies of this country.

It will be seen from the following figures that the increase of the telegraph business from the commercial standpoint has also kept pace with the improvements in the systems, apparatus and conductors of the telegraph service. Thus, from a few hundreds of thousands of telegrams handled per annum in 1868, the telegrams now handled, in this country alone, have reached the enormous number of seventy-five millions per annum.

The increase of wire facilities for the dispatch of this large volume of business has of necessity also been very marked during the same period.

For example, in 1868 there were but 120,000 miles of telegraph wire in this country, all operated as single wires. To-day there are close upon one million miles of "actual" wire in operation, to which may be added, at a low estimate, one-quarter of a million of so-called phantom wire, obtained by duplexing and quadruplexing "single" wires. Furthermore, thousands of miles of these wires, besides being duplexed, are now carrying telegrams at the rate of from 100 to 300 words per minute, by means of the Wheatstone automatic system.

All of which, it is thought, will tend to bear out my opening assertion, and will also show that electrical telegraphy still maintains a steady onward progress.

The Birth and Growth of Telephony.

BY THOMAS D. LOCKWOOD.

IN 1874 there was no speaking telephone. The possibility of the electrical transmission of speech had been recognized, and more than one person had indulged in the pleasures of the chase. By 1875 the idea which was the forerunner of practical success had been conceived, and the art of electrically transmitting speech had been embodied in a real working instrument; but not until 1876 was an electrical speaking telephone in the hands of the public.

The telephone was exceptionally fortunate in that it struck the Centennial year, and had the luck to be examined by such philosophical giants as Sir William Thomson and Prof. Henry, who did not scruple to pronounce it a scientific marvel, as wondrous as it was meritorious; and thus it came about that it entered the arena of public life with flying colors.

Many of us have vivid recollections of the childhood of the telephone—a brief epoch during the latter half of 1876 and the year 1877—when it appeared for a short space of time as though nothing more than a scientific toy (as it was termed by many) had been created—something forming an interesting subject for a short lecture, or a not too scientific amusement for a brace of telegraph operators when off duty.

Meanwhile its inventor and associates were not idle, and they improved the shining hour by devising improved forms of the instrument itself; suitable polarized bells; small but efficient magneto-electric generators adapted to actuate such bells; switches, manual and automatic, to facilitate the operation of the instrument and to improve the quality of its reproduced speech by withdrawing "resistance" and what subsequently has been named "inductance" from the circuit.

The earliest use of the instrument was in association with private lines, and though the magneto telephone had but a minute voice, such a one, in fact, as might be expected from a cheese-mite if it could talk, and required some experience and education before its utterances could be understood, it did good work, serving both as transmitter and receiver; and it is an interesting fact that the first telephone exchange commercially installed was equipped with such magneto telephones only.

The first line actually built for the operation of the speaking telephone was about two miles long, and was finished April 4, 1877. It extended from the factory of Mr. Chas. Williams, Jr., 109 Court street, Boston, to his house at Somerville.

Long-line telephony is supposed to be a rather recent development, but it also is among the achievements of the magneto telephone, for as early as the fall of 1877 communication was successfully effected between New York and Boston, and Boston and North Conway, N. H., by means of magneto telephones.

During the years 1877 to 1879, inclusive, marked progress in telephones, appliances and telephonic politics was made. We see the gradual introduction of the variable resistance telephone transmitter, based on the inventions of Berliner and Edison, and taking first the form of the carbon transmitter of Edison and later that of the well-known Blake transmitter, in which the variable contacts are provided with a delicate spring adjustment. The principles underlying these have, by the aid of Hunnings and later inventors, bloomed out into the powerful long-distance transmitter of the present time.

We see also in 1878 the microphone of Hughes, brought out in England in ignorance of the work done in the United States, and we cannot but note the deserved acclaim which greeted the publication of his researches.

The inception and the early growth of the now universally known exchange system also has its place in these years. There are many claimants to the honor of having first suggested this idea, but as they all know so much more about their own thoughts, sayings and work than they do about anybody else's, as a rule, they see one side of the shield only.

The truth is the telephone exchange to the intelligent telegraph man was self-suggestive, the telephone itself once having been produced.

We had already telegraph systems operated on the same plan. There were, for instance, the "Law" and Gold and Stock Bank systems in operation in New York, the local telegraph company in Philadelphia and a dial exchange in Newcastle, England.

In the Chickering Hall lectures of Professor Bell I myself heard him outline the workings of the telephone exchange. This was in May, 1877, and in the same month of the same year an experimental exchange was operated in Boston.

However, the first commercial telephone exchange was opened in February, 1878. There are now more than a thousand such exchanges.

The determination of the Western Union Telegraph Company in 1878 to enter the telephone business had one remarkable, though unforeseen, result, viz.: In the race between the rival companies, each to get ahead of the other, the principal cities of the country were provided with telephone exchanges supplying service long before such a condition of affairs could otherwise have taken place.

Such a race in the nature of things was not profitable, and about the end of 1879 the two parties reached an amicable understanding; the National Bell Telephone Company and its successor from that time alone carrying on the telephone business.

The telephone exchange is, of course, the principal industry connected with the instrument and art, and any one can see that a connection with a large exchange means virtually a private line and a bonus in the form of a good genius acting to provide from one thousand, say, to six thousand distant ends for such line, and a like number of different stations with which it can connect. It is easy to show that such a convenience is not merely the great time economizer of the world, but that the average cost to the user in a large city of each complete conversation is actually less than the cost of sending a letter.

Over 560,000 telephones are to-day in use in the country, and it is estimated that in the year 1893 some 650,000,000 conversations (in round numbers) took place by means of the telephone.

In 1884 the telephone in this country alone furnished employment to about 4,800 persons; and at the present time it employs upward of 10,000 persons directly and a host of others indirectly.

The long-distance business, as we now understand it, does not go further back than 1884 or 1885, but since its introduction it has strung many circuits between New York and Philadelphia and New York and Boston; a goodly number from Philadelphia to Washington; has brought the cities of the eastern coast in close communion with Chicago, Milwaukee and Cincinnati, and is now stretching out towards St. Louis; and it has truly been said that "soon it will not be a figure of speech to say that one-half of the population of the country is within talking distance of the other."

The telephone was the earliest electrical industry to recognize the importance of underground work, and conduits were constructed as early as 1882. Of course many mistakes were made as the work went on, but I do not think the same mistake was made twice; and, in 1894, nearly every large city in the United States has a first-class and well-built system of conduits containing telephone wires.

In 1877 there were no underground telephone wires; in

1885 there were in the United States but 1,200 miles; but at the present time, roughly stated, the figure stands at about 100,000 miles.

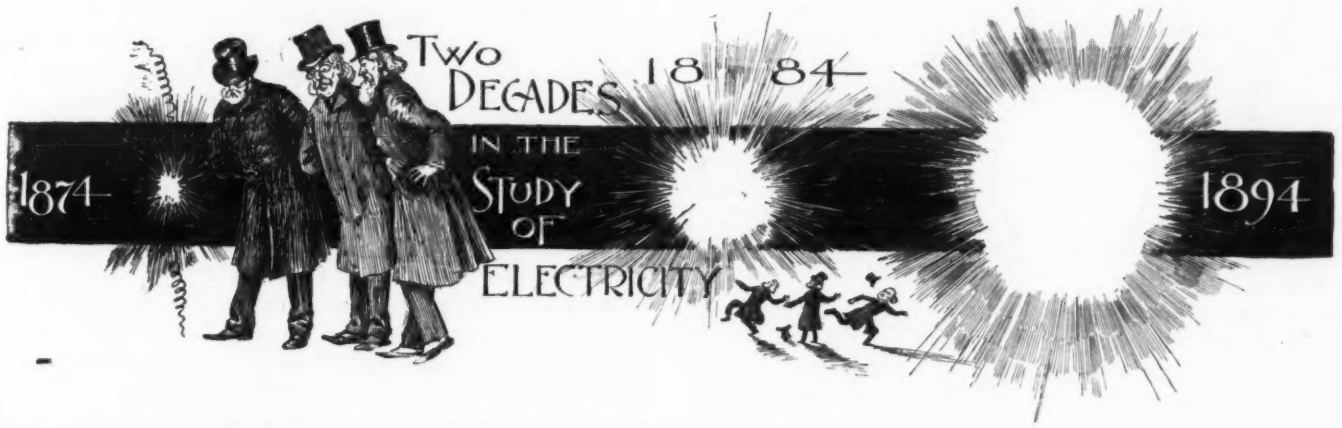
This work has reacted upon the manufacture of the cables occupying such conduits, producing corresponding improvements in them, which have resulted in cables of high and constant insulation resistance, and having capacity much lower than in 1874, and for many subsequent years would have been considered possible.

The invention of the telephone was the voice crying in the wilderness, announcing the speedy coming of electric illumination, power transmission, transit, and metal working, and the supposedly immense profits accruing from its installation and operation constituted the incentive for the thousands of other related and analogous, as well as dissimilar, inventions in applied electricity which during the following eighteen years have sprung into being.

The very inventions made in telephones and supposed improvements, and in devices made necessary by the telephone, such as calls, disturbance remedies, switchboards and appliances, automatic switches, cables, underground conduits, coin-controlled apparatus, exchange systems and multiple and compound systems are quite considerable in number, for, on Jan. 1, 1894, no less a number than 805 patents on telephones and 2,235 patents on telephone appliances and systems had since March 1, 1876, been granted by the United States Patent Office, representing more than $106,000 paid by inventors in this line to the Patent Office in fees alone.

Notwithstanding the immense development of this industry, it is evident that there is room to branch out into many fields of utilization which are, so far, relatively unploughed.

The immediate future of telephonic advancement will probably be in the direction of an increased number of private lines; in a considerable expansion of hotel, factory and institution installations for intercommunication between the departments, and to some extent in a renewed application to mining and, perhaps, also to diving operations.



The Last Two Decades in Arc Lighting.

BY EDWIN J. HOUSTON.

THE two decades through which the electrical world has just passed have witnessed remarkable activities in all directions. In the early part of the first decade these activities, though manifested in various lines, were most marked in the field of electric arc lighting. It would be impossible, in the limits of a brief article, to more than generally indicate the particular lines along which these developments have occurred.

After Davy and others had shown the possibilities of the carbon arc as a source of artificial illumination, numerous attempts were made to apply the arc to commercial use, and many excellent lamps were devised by Staite, Petrie and others, but there was practically only one electric source in those days; viz., the primary battery and the earlier efforts in the direction of commercial arc lighting were thereby rendered unsuccessful.

The invention by Gramme, in 1870, of his improved magneto-electric generator, and his subsequent inventions of a dynamo-electric machine and a self-exciting alternating-current generator, placed at the disposal of the world a cheap and reliable source for the production of electricity, and so rendered arc lighting a possibility.

The exhibition of the Gramme machine at the International Exhibition of 1876 in Philadelphia may justly be regarded as a circumstance which greatly tended in this country, and indeed all over the world, to turn the attention of inventors again to arc lighting.

Jablochkoff had already, on March 21 of that year, taken out a patent in France for his well-known electric candle, consisting of two parallel carbon rods, maintained at a constant distance from each other by a strip of non-conducting material. By means of this device Jablochkoff did away entirely with the expensive regulating mechanism employed in the earlier forms of arc lights for maintaining the carbons at a constant distance apart. Jablochkoff's invention created great excitement in the world, and was extensively introduced into use. It formed an important feature of the Paris Exposition of 1878, and was employed in the same year for street lighting in the Avenue de l'Opera in Paris. At first Jablochkoff employed the direct current in connection with his candle, but soon experienced a difficulty on account of the more rapid consumption of the positive carbon. He subsequently avoided this difficulty by the use of the alternating current in place of the direct current.

Despite its seeming simplicity, the Jablochkoff candle was soon found in actual practice to be far inferior to arc lamps employing larger carbons and containing more or less complex mechanisms for maintaining the carbons a constant distance apart, despite their consumption.

It would be impracticable even to name the various inventors who have competed with one another for superiority in the development of the arc lamp; suffice to say that of all the forms of lamps tried those in which the positive carbon is held vertically over the negative carbon and fed toward it by the action of gravitation were the ones that proved fittest to survive, and which are now extensively in use over the whole world. In all these lamps, with the exception of the lamp used with a projector in the search light, the upper carbon alone is fed. In the latter both carbons are fed.

Among the earlier inventors in the field of arc lamps are to be found Wallace, Wallace-Farmer, Brush, Maxim, Weston, Wood, Thomson-Houston, and somewhat later, Westinghouse, with his alternating arc lamp, and numerous others. In their earlier use arc lamps were employed on

single circuits. Brush was one of the earliest, if not the earliest, to adopt series lighting in this country. That is, he placed a number of arc lights in series on a metallic circuit.

The use of the series circuit in arc lighting must be regarded as a step of the greatest importance in the history of the arc light, for the series circuit readily affords the means for the distribution of a great number of lights over a large area, with a comparatively small weight of copper conductor.

But before series arc lighting could become a possibility an invention fundamental to the art was required; viz., the production of the derived circuit lamp, which finally developed into the differential lamp; that is, a lamp in which a regulating device is placed in a shunt circuit around the arc established between the carbons. An electromagnet placed in the shunt circuit is employed to antagonize the action of a magnet placed in the main or arc circuit, and employed to separate the carbons. It acts briefly as follows: When the carbons burn apart, and the resistance of the arc formed between them consequently increases, a greater proportion of current passes through the shunt magnet and energizes its coils sufficiently to permit the release of a clutching device, thus leaving the upper carbon momentarily free to fall toward the lower carbon.

Like all great inventions, the derived circuit lamp and the differential arc lamp were the gifts of many inventors. The first lamps of this type were produced by Lacassagne and Thiers in 1855. Subsequently Lontin, De Mersannes, Brush, Siemens and others greatly improved them.

The use of the series circuit in arc lighting at once demanded the invention of a safety device, whereby the extinguishment of any one of the lamps placed in the series circuit should not destroy its continuity. This invention, therefore, was made early in the history of the art, and was practically contemporaneous with the production of the series system in arc lighting.

The enormous development of arc lighting soon rendered the artificial carbon or graphite formed on the interior of gas retorts, in which soft coal had been carbonized for the production of illuminating gas, insufficient in quantity, and various manufactories were established for the production of artificial carbons. Artificial carbons consist mainly of mixtures of carbonaceous and carbonizable materials, moulded into form and subsequently carbonized.

All such artificial carbons are greatly improved by an electrolytic deposit on their surface of a thin coating of copper. A French patent was taken out for such a process by Reynier under date Oct. 11, 1875, and Jablochkoff employed such a coating early in the use of his invention. Reynier, however, was anticipated in this event by Carre, who took out a patent in France, Aug. 23, 1867, in which he describes carbons coated with zinc and tin for electric light purposes. So, also, Van Malderen claims to have coated carbons with copper in 1867, and Bouliguine and Tchikoleff appear to have coated carbons with copper about the same time. In America Brush took out patents for copper-coated carbons early in the history of arc lighting.

Arc lights are peculiarly adapted to outdoor lighting; i. e., to the illumination of extended areas, and this requires the burning of a light, in many cases, during all the hours of darkness. It soon became evident from the limits of the dimensions which it was found practicable to give the ordinary arc lamp, and the size of the carbons best adapted to insure steadiness of light that a single pair of carbons, a long upper or positive carbon and a short lower or negative carbon, would not suffice to last through the hours of darkness. In the early history of the art it was customary for trimmers to climb the poles and recarbon the lamps while the rest of the circuit was in operation. A great improvement was introduced into arc lighting by the invention of the all-night arc lamp. The disc regulators of Harrison, in 1857, were the prototype of this form of lamp. In America Wallace's plate-carbon lamp was a step in the right direction; but the type of all-night lamp which is now almost universally employed in America is the double-pair carbon arc lamp. The priority of this invention has been awarded by the courts of this country to Brush.

The production of a good dynamo for use in connection with series arc lamps was a problem that was solved early in the history of the art, and a variety of excellent dynamos have been invented for this purpose, namely, the closed-circuit dynamos of Weston, Maxim, Wallace-Farmer, Wood, Hochhausen, and the open-circuit dynamos of Brush and Thomson-Houston.

The past two decades have witnessed a wonderful development in arc lighting. Will the next two decades witness an equally marked improvement, or will the arc light be, to a certain extent, replaced by some other form of light, say, for example, an improved, high-candle power, incandescent lamp?

The Growth of Incandescent Lighting.

BY W. A. ANTHONY.

IT is now almost a hundred years since it was first observed that a metallic wire could be heated to incandescence by the passage of the electric current. And yet it may be said that twenty years ago the history of incandescent electric lighting had hardly begun. From almost the beginning of the century scientists experimented upon the heating of conductors by the current and studied and formulated the laws governing the rise of temperature. Teachers of electrical science performed for their classes experiments in which wires were heated to redness and melted by the current. And yet up to twenty, or even fifteen years ago, little was done toward the use of such incandescent conductors for the purpose of illumination. The slow progress in those early days was due undoubtedly to the cost of electrical energy, for which there was no cheaper source than galvanic batteries. It was not until the great improvements in magneto and dynamo electric machines, 1866 to 1871, resulting in the continuous-current machines of the Gramme and Siemens types, that electric lighting became commercially practicable. Two ways were open for the application of the current to the production of light—the electric arc and the incandescence of small conductors. The intense brilliancy of the arc light, and especially the fact that, for the energy expended, so large a return in light was rendered, led experimenters to the perfection of regulators for arc lamps to the neglect of the methods of lighting by incandescence. But, although dynamo-electric machines and regulators for the arc light were at hand in 1871; although carbon in vacuo had been used for an incandescent lamp in 1845, the subdivision of the battery current for the operation of incandescent lamps had been achieved in 1859, and the subdivision of the dynamo current for the same purpose in 1871; yet at the Centennial Exhibition in Philadelphia in 1876 no one was ready to furnish electric light for any of the buildings or any portion of the grounds. Dynamo-electric machines were there, and arc lamps were there, and they were sometimes shown in operation, but nowhere were they depended upon for illumination. Up to 1876, therefore, there was no commercial electric lighting system. In 1871 Lodyguine exhibited in St. Petersburg 200 incandescent lights operated by one machine*; in 1875 Farmer operated

*"Nature," XIX., 52.

by means of one machine 42 platinum lamps, but these experiments attracted little attention and were soon forgotten. The two or three years following 1876 saw the arc light rapidly assume importance in outdoor and large area lighting, but all attempts to make a small arc light suitable for domestic lighting failed. Any attempt to reduce the brilliancy of the light was attended by a loss in efficiency. It seemed to follow somewhat the law of gas lights, where, as is well known, a small burner gives, in proportion to the gas consumed, much less light than a large one. This loss in efficiency seemed to be fatal to the "subdivision" of the light to any such extent as was needed for general indoor illumination. It was known that incandescent lights could be made as small as desired, but incandescent lights gave, for the energy consumed, only about one-tenth the light of the arc lamp, and this was enough to deter many experimenters from seeking the solution of the problem in that direction.

There is a mistaken idea that eminent scientific men about that date, 1877-1879, declared the subdivision of the electric light impossible. Nothing is further from the truth. What scientists did say was that it seemed to be impossible to subdivide the light and maintain the efficiency obtained by the electric arc, and that is as true to-day as it was then. That problem in the subdivision has never yet been solved.

At the beginning of 1878 the position was this: The laws governing the subdivision of electric currents and the fall of potential along conductors—all the laws and principles involved in the proportioning of conductors for distributing electric currents—were well understood. For at least twenty-five years these laws had been considered in making designs for electrical instruments and apparatus; they had been taught to college classes and questions and problems based upon them had been given at examinations. The dynamo-electric machine was well developed, and needed only to be properly proportioned to adapt it to the supply of energy for incandescent lamps. Incandescent lamps had been made with platinum and other metallic burners, and also with burners of carbon. Currents from a galvanic battery and from dynamo-electric machines had been divided among a number of such lamps. What was lacking was a cheap and durable lamp, a willingness to accept the low efficiency of incandescent as compared to arc lights, and a demonstration that the distribution could be effected and the system operated upon a commercial basis.

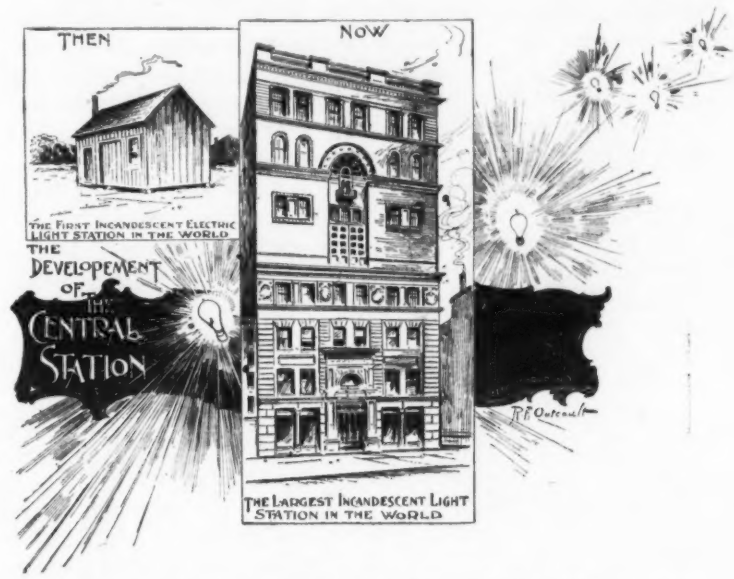
Fortunately, a few workers in the electric lighting field had confidence in the incandescent lamp, notwithstanding the waste of energy its use involved. Sawyer and Man, Edison, Maxim, Swan and others turned their efforts in this direction, and the success of the incandescent lamp is due in some degree to each of these. A lamp possessing the elements of commercial success was completed by Mr. Edison in the latter part of 1879, and in the latter part of December in that year an exhibition plant was started at Menlo Park by which the streets and many of the buildings, including private residences, were lighted—the first example of house-to-house lighting that approached the fulfillment of the conditions necessary to commercial success.

In the May following the first commercial plant to use the Edison lamps was installed and started on the steamer Columbia. But the other workers in the field had not been idle. Successful lamps had been made by Maxim, and in the autumn of 1880 a plant of about fifty Maxim lamps was started in the Equitable Building, at 120 Broadway, New York City. This was the beginning of commercial incandescent lighting in New York, only a little more than thirteen years ago. Since that date the growth of incandescent lighting has been marvelously rapid, and yet there has been no striking or fundamental change from the methods and apparatus used in those first plants, except the introduction of the alternating system in 1886-1887, which, permitting the use of high potentials, solved the problem of distribution in suburban districts and small places, where consumers are scattered over large areas.

Lamps have been improved by improvements in the manufacture of filaments, adapting them to use at a higher temperature, by which it obtained a higher efficiency. Within a year the lamp has been still further improved by the substitution of an artificial atmosphere of bromine for the vacuum in the lamp chamber, which, although it may shorten the life of the filament, certainly prolongs the useful and efficient life of the lamp.

Generators have been somewhat improved in efficiency and regulation, and they have, of course, increased in size with the demand for larger plants.

Probably the greatest improvements have been made in the methods of wiring buildings and such details as cut-outs,

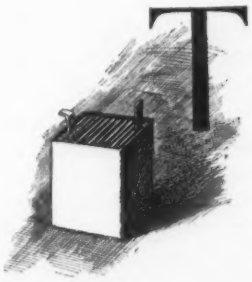

THEN
NOW
THE FIRST INCANDESCENT ELECTRIC LIGHT STATION IN THE WORLD
THE DEVELOPEMENT OF THE CENTRAL STATION
THE LARGEST INCANDESCENT LIGHT STATION IN THE WORLD

switches, etc., in response to the demands for safety, convenience and good taste.

The most striking evidence of the growth of the incandescent lighting industry was seen in the plant that was installed and started last year at Jackson Park, just about thirteen years after the plant at Menlo Park, and there could be no stronger evidence of the activity in that line than the fact that one manufacturing company alone was able to take and execute a contract to furnish for that plant nearly 100,000 incandescent lamps with all the machinery and appliances required for the complete installation.

The Storage Battery from Its Introduction.

BY TOWNSEND WOLCOTT.



THE history of the development of the storage battery in the last twenty years practically includes its whole history. The first recorded instance of the observation of electrolytic polarization is that of Gautherot, in 1801, who discovered that platinum or silver wires which had been used to desaline water electrolytically, possessed the property, after having been cut off from the original source of currents, of themselves furnishing a current of short duration in the reverse direction. Ritter, in 1803, observed the same phenomenon with gold wire, and made the first secondary battery by superposing pieces of gold, separated by cloth discs, moistened with a saline solution. Subsequently Volta, Davy, Becquerel, Marianini and others added somewhat to the knowledge on the subject, and Sir William Grove, in

1842, constructed his well-known gas battery, in which the E. M. F. came from the oxygen and hydrogen evolved in the electrolysis of water acidulated with sulphuric acid. Faraday, when electrolyzing a solution of lead acetate, found that peroxide of lead was produced at the positive, and metallic lead at the negative pole of the electrolytic bath, and in his "Experimental Researches" he comments upon the high conductivity of lead peroxide and its power of readily giving up its oxygen. This may be considered the next step in the evolution of the storage battery, although Faraday apparently made no such use of it. According to Niblett, Wheatstone, De la Rue and Niaudet all seem to have been well aware that peroxide of lead was a powerful depolarizer, but the first cell which could be called in any proper sense a practical storage battery was made by Gaston Plante, who, in 1860, constructed his well-known cell with coiled plates. This cell was made by rolling into cylindrical form two long, narrow plates of lead, separated by thick cloth, and placing the roll on end in dilute sulphuric acid. Plante made further improvements in his apparatus, and advanced the art so far that he may be considered, more than any other one man, as the inventor of the modern storage battery. Plante's researches extended up to the year 1879, and in the year 1874, which is the beginning of the period which we are here especially considering, they practically determined the state of the art. As to the theory at that time, it may be stated that in the year previous Maxwell published his treatise on electricity and magnetism. So great was the merit of this work, that it at once placed its author in the position of the leading electrician of his time the world over; and yet the only way in which Maxwell speaks of the storage battery is as storing up a charge of electricity in a manner somewhat analogous to the ordinary condenser (or accumulator, as he calls it by preference, which is the name since applied by some authors to the storage battery itself). To-day the theory of the storage battery differs in no respect from that of the primary battery; the current and E. M. F. depend in the same manner upon the amount of electrolysis and the energy of the chemical action, and the distinctions once considered so important are really differences of practicability rather than of principle. That is to say, in any primary battery where the chemical action which takes place during the discharge can be reversed by a reverse current from an outside source, we have theoreticaly a storage battery, and on the other hand a battery which, as ordinarily made, is not active until charged from an outside source, may be made active at once by the use in the first instance of those chemical substances which are otherwise formed by the outside current. The Plante cell, as is well known, consists essentially of two lead plates, which, by the prolonged action of the "forming" current, are converted to a greater or less extent, the one into metallic lead in a spongy condition and the other into peroxide of lead. This type of cell, in the hands of its inventor, gave results far surpassing anything ever obtained, or even hoped for, from primary cells, yet, nevertheless, it fell far short of what was necessary in many commercial applications. The process of manufacture was tedious and expensive, and the life of the positive plates was short, owing to the oxide falling off. In 1881 Camille A. Faure conceived the idea of avoiding the tedious forming process by applying mechanically to the lead plates a coating of minium, or other oxide of lead, which was held in position by felt covers, and which was converted into peroxide and spongy metallic lead on the positive and negative electrodes, respectively, much more quickly and economically than in the Plante type of cell. It was one of these Faure cells which was sent to Lord Kelvin (at that time Sir Wm. Thomson), and which caused his now famous letter to the "Times" about a "marvelous box of electricity" in which "a million foot-pounds of energy" had traveled from Paris to Glasgow. These remarks, coming from so high an authority, gave a great impetus to the storage battery industry, and inventors began to crop up at a rate that was truly astonishing. Sellon and Volkmar introduced the "grid," or grating, to which the Faure paste was applied, and which supported the latter so well as to obviate the necessity of the felt. This was a real improvement, but after the first grid appeared dozens of so-called inventors, who had merely altered the form of the grid, came forward, each claiming to have a new battery. The Faure-Sellon-Volkmar cell, with some minor improvements, is practically the cell of to-day, of the mechanically applied oxide type. Charles F. Brush worked independently in the same field with Faure, and the United States courts have after lengthy litigation decided that priority in this country belongs to Brush.

On the other hand, many claim that the mechanical application of oxides was discovered, or invented, by Plante himself. The Plante type proper has been greatly improved of late years, and to-day has no favors to ask from the Faure type, even if it is not really better, as it is believed to be by many. The Laurent-Cely, or chloride, cell has come into prominent notice of late years in consequence of undoubted merit. The cell belongs to the Plante type, but is manufactured by a process peculiar to itself. Blocks are first cast from a mixture of the chlorides of lead and zinc, and the chloride of zinc removed by washing. The blocks are then placed in a mould and the grid cast around them. The chloride of lead is then reduced by metallic zinc, and the plates then formed in a manner similar to the Plante disintegration process.

We can here only briefly touch upon two other types of storage battery, omitting all others as having so far attained no commercial importance.

By replacing the spongy lead plates of the Plante or Faure types by metallic zinc the E. M. F. is materially increased, but new difficulties are introduced, which interfere with the commercial operation of the cell. These difficulties have been largely overcome by later inventors, so that this type holds its own commercially, though it has not materially interfered with the Plante and Faure types. The first use of the confination of zinc and peroxide of lead appears to have been by Wheatstone in 1843. The battery of Commelin Des Masures and Bailhoche consists of zinc and copper electrodes in caustic alkali. This type has in the last two or three years attained a good deal of importance in this country in the hands of Waddell and Entz. All the types described are in commercial use to-day, and mark a considerable advance since 1874.

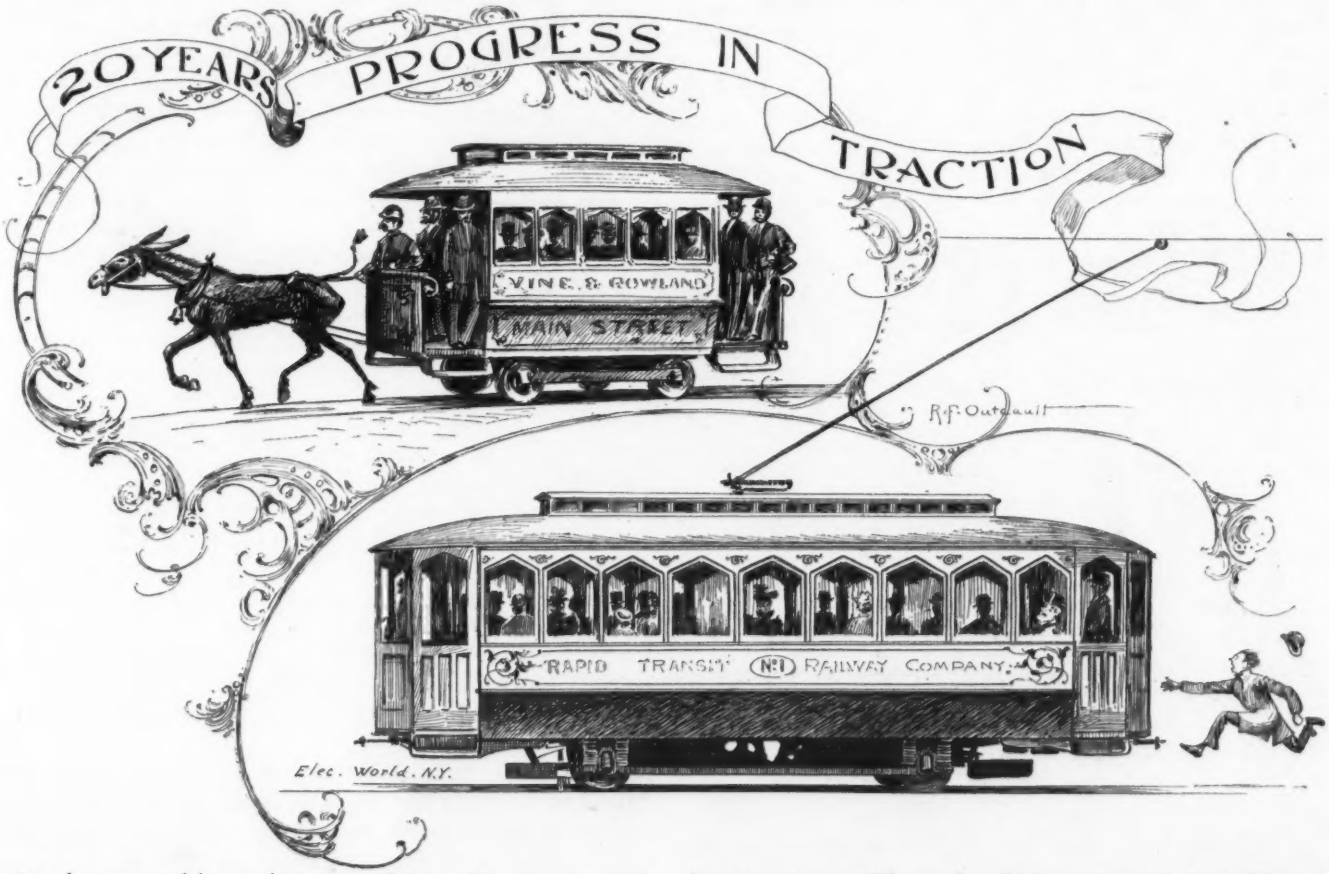
In Europe storage batteries are largely used in central stations for equalizing the load. They are charged from the dynamos during the hours of light load, and discharged in connection with the dynamos during the hours of heavy load. They are also beginning to be used in the same manner in this country, and it is to be hoped that they will come into more general use. In the field of lighting of railway trains they are also doing good work in this country. On the Continent of Europe the most popular types for station work are those which are very heavy in proportion to their output, in consequence of their greater durability. For traction purposes, however, the great desideratum is lightness in proportion to output, necessitating a different construction. The alkaline battery is remarkable for its lightness in proportion to its current output, but as its E. M. F. is only about three-eighths of that of the lead and sulphuric acid types, its watt output per pound weight is not larger than in some makes of the latter kind. Storage battery traction has thus far been chiefly experimental, but its promoters are still confident of ultimate success, which all will admit as highly desirable.

The Development of Electric Traction.

BY CHARLES HEWITT.

SO far as we now know, electric traction had its beginning some time in the thirties of this century, and slumbered for many years, with an occasional awakening, until Mr. Charles Van Depoele and Mr. Leo Daft took up the subject. These inventors had the advantage over all their predecessors in that they had the dynamo in a fair state of development. They worked on similar lines, and built several roads with the double trolley wire and overrunning trolley, and with motors mounted on the car platform. The few roads built on this plan demonstrated two things—the feasibility and the demand for electric traction. Although thoughtful railroad managers saw in this system the beginning of a future revolution, still they held aloof. It was too crude, too mysterious, too new, too radical. The onus of expense fell heavily upon the inventors and their friends. Nor was the battle yet to be won without the expenditure of large sums of money and the exercise of undaunted energy and pluck. In 1885 or 1886 Mr. Sprague astonished the electrical fraternity by his plans for the equipment of the Richmond Street Railroad—motors placed beneath the cars, geared directly to the axle and flexibly suspended from the car body or truck; a single trolley wire with an underrunning trolley; an earth return circuit. As we look back we cannot but admire the pluck of the man who conceived and the men who caried out his ideas; no precedent to go by, everything was to be demonstrated. Be it said to their credit that the "system" in all its essentials remains to-day as it was then conceived. The apparatus has been wonderfully developed and improved, but the "system" remains unchanged, and has relegated its older brother to utter oblivion. Perhaps the whole history of the Richmond road will never be written, but it is now well known that the experience gained there cost the promoters many thousands of dollars. But the loss of thousands then has been offset by profits of millions since. "To err is human" applies most truthfully to this road. Not to have made some mistakes would have been supernatural. When two indifferently fed mules could give a service that was thought to be satisfactory, it was natural to suppose that two 5-h. p. motors would answer all requirements. But with the new method of propulsion, new possibilities were revealed. People were no longer willing to jog along at five or six miles an hour behind two stumbling animals. A cry for more rapid transit arose, and a demand for more powerful motors, until the original 5 h. p. has grown to 30 h. p. and for locomotives even to 200 h. p. Among those who early realized the value of the Richmond experiment was Mr. Henry M. Whitney, president of the West End Railway Company, of Boston. By the signing of the contract for the electrical equipment of the West End Railway, electric traction was given an impetus that was simply phenomenal.

Imperfect as the apparatus at that time was, the demand for it soon grew to be overwhelming. In five years the business had grown from nothing to no less than twenty million dollars for one year's sales. Is it not remarkable



that so many millions should have been invested in apparatus that in less than ten years has been entirely superseded, and in a large measure replaced and relegated to the scrap heap? What hopes were blighted; what illusions dispersed by those early motors. The promises of the enthusiastic salesmen were so far from being realized that these men were considered just candidates for eternal punishment, and yet I believe in most cases they honestly believed their rosy stories. All thought each new type of motor would overcome all the troubles in the former type. But armatures would burn out and, in fact, each type seemed to develop faults peculiar to itself. The old No. 5 Sprague motor, with its two commutators, soon gave place to the No. 6 motor, with one commutator, larger fields and more powerful armature. This was followed by the No. 8 Edison motor, with improved frame and wound for 250 volts, the two motors on a car being connected in series. This in turn was followed by the Edison multipolar motors with Gramme

ring armatures, Nos. 10, 12, 14 and 16. Each of these types went through a development of its own before giving way to a succeeding type. One feature, however, was common to the Sprague and Edison motors, viz., regulation by commutation of the field coils.

Contemporaneously with these motors appeared the Thomson-Houston F 20 and F 30 motors—bipolar motors with drum armatures. These were followed by the S. R. G. 30 and S. R. G. 50 motors with Gramme ring armatures and single reduction gears. No improvement heretofore had been so marked as this change to slow-speed motors with Gramme ring armatures. The Westinghouse company was somewhat late in entering the field, but it finally brought out a bipolar high-speed motor with drum armature, resembling in many respects its competitors, but differing especially in the design of its supporting frame. This was followed by a motor of similar design, but with single reduction gears runing in oil or grease. All the motors up to this time were much exposed to the water, mud, dust and slush in the streets, and it became evident that some radical change in design must be made to protect the motors from such rapid deterioration. Finally Mr. W. H. Knight, so well known in connection with the Bentley-Knight company, designed for the Thomson-Houston company his W. P. (water-proof) motor, with its single field coil and Gramme ring armature. This type, known in England as the "box" type, marks a most decided improvement. The Westinghouse company soon after brought out its "box" motor, which is essentially its motor of to-day. The latest motor is the G. E. 800, made by the General Electric Company. It is a multipolar motor of the box type, with either drum or Gramme ring armature. Other motors than those referred to have at various times been put upon the market, but of these it is only necessary to refer to two types, viz., the gearless and the single motor geared to both axles. The gearless motor for street car service is probably only a dream of the past. Howsoever desirable such a motor may be, it is more than likely that the single reduction motor will monopolize street car work for a long time to come. Mr. Short's work on the gearless motor, however, has not been entirely in vain, for the 1,200-h. p. B. & O. locomotive is made up of six 200-h. p. motors, built substantially on the lines of one of Mr. Short's street car motors. The single motor geared to both axles was first introduced by Mr. Frank Rae, and was received with considerable favor, but the results were disappointing. Lately Mr. Elmer Sperry has developed a single motor equipment, with a slow-speed motor, flexibly suspended. Such an equipment is certainly to be desired, on account of its greater simplicity, and we will watch the success of this apparatus with much interest.

Space prevents mentioning the many and important improvements that have been made in the various devices that go to make up a car equipment, but perhaps the change in controllers is the most marked. The controlling device is of the utmost importance, and is second only to the motor itself. As before stated, the Sprague company and its successor, the Edison General Electric Company, adhered to the commutated field method of control, with the well-known barrel switch. At first the resistance of the fields was relied on entirely, and how well we remember the complaint that passengers were compelled to sit several feet from where they expected to, or perhaps in somebody's lap, due to the sudden starting of the car. Other manufacturers used the rheostat method of control almost entirely. Almost every style of rheostat that human ingenuity could devise was tried. Some were better than others, but all were troublesome. The present method of control is a combination of all previous methods, with the additional one of commutating the wires.

The development of the power-producing machinery has gone on simultaneously with that of the motor. New engines have been designed to meet the requirements. The compound and triple expansion type have largely replaced the single cylinder. Multipolar generators of largely increased output have replaced the small high-speed bipolar machines. Perhaps the highest development has been reached in the slow-speed generators coupled directly to the shaft of the engine, dispensing with all belts and countershafts. The step from the 40-kw. machines of 1889 to the 1,500-kw. direct coupled generators of 1893 tells its own story.

And what shall be said of the future? Is the alternating-current motor to have no place in this wide field of usefulness?

The Electrical Transmission of Power During the Past Twenty Years.

BY CARL HERING.

SETTING aside telegraphy as being a transmission of signals rather than of energy, a review of the progress made in the electrical transmission of power since the birth of this journal should include practically the entire history of this branch, with the exception of what we might be permitted to call the very first application, by which we refer to the amusing experience of one of the earliest electricians of history and the greatest of his time, Benjamin Franklin, who, in the year 1749, entertained some friends by transmitting the charge from one of his machines through a wire across the river Schuylkill, at that time a few miles from Philadelphia, and killing a turkey with the transmitted electricity, after which he roasted it by an "electric jack" in a fire kindled by the transmitted electricity; the feast was completed by drinking "the health of all the famous electricians of England, Holland, France and Germany in electrified bumpers, under the discharge of guns from the electric battery"; what the "electric jack" was is not described, but "an electrified bumper" is explained as being a glass of wine electrified while held in the hand, as if it were a Leyden jar, so as to give a shock "if the party be closely shaved and does not breathe on the liquor." That Franklin appreciated other good things besides a joke, and electrical experiments, is shown from his remark that "the birds killed in this manner eat uncommonly tender."

But to return to the subject: Although motors with permanent magnets had been long known, the electrical transmission of power on a practical scale really owes its origin to the accidental discovery of reversibility of the self-excited dynamo, which occurred, if our recollections are correct, about the same year as the one during which this journal was started. It is said to have been due to an error made by a workman at an exhibition in Vienna, who connected one of the old Gramme machines to the wrong circuit; the circuit being that of another machine which was running, he noticed that the dynamo which he had just connected started to revolve, generating considerable power. This little incident was followed by an investigation of the subject by the physicists and mathematicians, and with their usual activity the latter at once developed all sorts of theories, some of which, though correct, were so misleading that it is to be regretted that they were ever published, as it checked progress in the right direction. They informed us that the best conditions were those which we now know to be the worst, and it took some time before these wrong impressions could be eradicated.

The next year was one in which much time and paper were wasted in mathematical theorizing, but still it resulted in several important conclusions, among which were a more thorough understanding of the action and meaning of the counter E. M. F., of the true mathematical relations in the whole transmission, etc., which laid the foundation for future progress. Marcel Deprez, who at that time gained the great fame which he afterwards lost again, made the well-known experiment near Munich in 1882, about which so much was written at that time, all of which is now merely of historic interest. The great importance of high tension was then being recognized, but the Gramme machine, which he used, could not stand such high voltages. Elaborate tests were made, but only a few important results were obtained, one of which was that that installation was not a success; the failure, however, being due to the insulation of the armature, or more correctly speaking, to the want of proper insulation.

About this time the advantages of electric motors began to be appreciated in the United States, and although no important transmission of power installations were made, yet a foundation was being laid in the perfection of the motors. Distances gradually became longer, and soon the rapid that it would be hard to find an equivalent development in any other industry. In Europe the introduction of electric railways, which were not experimental, began later, after the commercial success had been fully demonstrated here.

The boldest and most daring experiment in the electric transmission of power was made in 1891, between Lauffen and Frankfort, in Germany, a distance of over 100 miles. The motor—the missing element in alternating-current transmission—having been supplied by the multiphase system, two of the largest firms in Europe combined to make a practical demonstration, which, in long-distance and high tension, far surpassed anything before attempted. The results of the official tests may, perhaps, be of some use to our grandchildren as historical records, we, in the present generation, having given up all hopes that the easy-going professors will finish their calculations in time for us. But although these promised results of the tests are already too old to be of much use, many valuable conclusions may be drawn from this experimental installation. The possibility and even the practicability of using such high voltages was demonstrated; also their danger. The efficiency was very good, distribution was shown to be possible, and the importance of a number

electrical transmission of power was no longer an experiment. Meanwhile the high-tension alternating current transmission was introduced, and although this solved the problem of long-distance transmission of electricity for lighting, motors were wanting to enable it to be used for power purposes; it is only quite recently that the latter want has been filled, at least in a modified alternating-current system.

While transmission combined with distribution to many small motors was developing rapidly in this country, the simple transmission from one generator to a single distant motor was receiving more attention abroad, especially in Switzerland; the contrast between these two different directions of development was shown very well at the exhibits of the Paris Exposition in 1889. The application to electric railways, although begun early in the eighties, did not really emerge from the experimental state until about 1888, after which year its progress in this country was so

of factors, such as the frequency, the static capacity of the line, etc., was shown. In this particular installation the cost of the transmitted energy was greater than that produced by coal at Frankfort, even though the water power at Lauffen cost nothing but the machinery to utilize it. This was due to the great cost of the installation. This, which has been made use of by some to pronounce the test a failure, is of no real importance to the electrical engineer, as it was never intended that this plant be used for that city; the object was to demonstrate the possibility of such a system even under exaggerated conditions, and thus to show to the skeptical that it would be practicable under more favorable conditions. Where coal is expensive, that same plant would doubtless have been a commercial success.

Up to within the last few years there was still a certain experimental element in all but the smallest installations, but

now even the most skeptical advocates of the hydraulic and compressed air transmission admit that up to moderate distances electrical transmission is no longer an experiment and has advantages over its older competitors. Electrical transmission has been used side by side with hydraulic and pneumatic. It has gained ground which the latter have lost. No better proof could be desired. At first it was decided to use both compressed air and electricity in the great Niagara Falls plant, but little is heard now about the former, from which it appears that it has been abandoned.

The field which is now entering its experimental state is the very long-distance transmission and the transmission of very great powers, in both of which new elements enter. Distances of ten miles are now almost every-day matters, as are also transmissions of several hundred horse powers, but in the present year schemes are seriously proposed of such magnitude that they can well be said to open up an entirely new field. Besides the Niagara Falls plant, which is no longer a mere proposal, other plants of enormous proportions are being considered. It is proposed to supply the whole Kingdom of Saxony with light and power from one central station near a coal mine; the currents in the Bosphorus may be used for lighting Constantinople; St. Petersburg may be supplied with light and power from a distant waterfall in Finland; it is proposed to send heavy trains of cars, not light pleasure cars, across the Alps by means of the water power which at present is running to waste side by side with the railroad. Although it may take some years to carry out such bold projects, there is little doubt that at least some of them will be begun before many years. The main question is not so much whether it can be done, but whether it would pay financially to do it.

That high voltages must be used is evident; how high is a question which can be decided only by experiments and not by theory. Prof. Elihu Thomson, whose propositions, though sometimes very bold, are not of a wild character, suggested two years ago transmitting by means of three-phase currents 130,000 h. p. over 240 miles at 500,000 volts through small wires contained in an iron pipe and insulated with cheap cotton and oil. Although this is still, as it was then, a mere prediction of future possibilities, it is nevertheless interesting, as it comes from one who is able perhaps better than any one else to make such a prediction.

Regarding the future, it is no doubt safe to say that continuous currents have reached nearly, if not quite, their limit in high voltages, and that therefore very great distances or very large powers through small wires are beyond the sphere of continuous currents; should a commutatorless continuous-current machine for high voltages ever make its appearance, which seems quite unlikely, this field will be opened again for continuous currents. More debatable questions are the relative merits of single and multiphase alternating currents, the main factor in which is the motor. A single-phase alternating-current motor as satisfactory as a shunt or series continuous-current motor would probably decide the fate of multiphase systems, at least in many transmissions in which their other advantages are not important. It would not be safe to predict that such a motor was not forthcoming, and until it has been shown that its invention is unlikely, it will be wise to be cautious in choosing between the two systems; at present the best multiphase motors seems to be better than the best single phase. The combination of the two systems, as in the Niagara Falls plant, admitting the use of either or both of the two different-phased currents, and even the use of continuous-current motors slightly modified, seems to be a good and safe happy medium. The most important debatable questions are those concerning the best frequency and voltage, about which it will not be possible to arrive at any indisputable conclusions until more reliable data are at hand for making comparisons which are free from personal opinions. When the behavior of high voltage alternating currents is more thoroughly understood and admits of definite calculation, and as soon as the results of using different frequencies can be reduced to dollars and cents, then the "parallel column method" will decide very quickly and definitely what the best probable values will be in each case. These two questions and the construction of a satisfactory single-phase alternating-current motor, or a proof that it can never be satisfactory, seem to be to-day the most important of the uncertain factors in the long-distance transmission of power.

Programme of the Washington Convention.

The annual meeting of the National Electric Light Association at Washington this week bids fair to prove one of the most interesting of the long series of successful gatherings which this organization has already held. The programme, which is given below, is an attractive one and will probably receive a thorough discussion, as the attendance promises to be larger than at any previous convention. Following is the programme in detail:

TUESDAY, FEBRUARY 27, 1894.

Meeting of the Executive Committee, at 9 A. M., Parlor 36, Ebbitt House.

Morning session, 10:30 o'clock, Grand Army Hall.

Address, President E. A. Armstrong.

Report, Committee on Legislation, C. H. Wilmerding, chairman.

Report, Committee on World's Columbian Fair, B. E. Sunny, chairman.

Report, Committee on Relation Between Manufacturing and Central Station Companies, Frederic Nicholls, chairman.

Afternoon session, 2 o'clock.

Report, Committee on Data, H. M. Swetland, chairman.

Report, Committee on Finance, John A. Seely, chairman.

Report, Committee on Underground Conduits and Conductors, M. J. Francisco, chairman.

Report, Committee on Rules for Safe Wiring, William J. Hammer, chairman.

Paper, Lucius T. Stanley and Walter E. Harrington, "Faults Incident to the Protection of Lighting and Power Circuits." Questions and Answers. What is it You Wish to Know?

Executive session.

WEDNESDAY, FEBRUARY 28, 1894.

Morning session, 10 o'clock.

Paper, J. H. Vail, "The Importance of Complete Metallic Circuits for Electric Railways."

Topic, "Electrolytical Effects of Return Currents." Discussion.

Topic, "Storage Batteries." Discussion.

Report, "Electric Light Tests at Buffalo," Charles R. Huntley. Discussion.

Afternoon session, 2:30 o'clock.

Paper, A. B. Herrick, "Development of Switch Boards for Modern Central Stations."

Topic, "What is the Most Economical Size for Arc Dynamos?" Discussion. Charles R. Huntley, George A. Redman, E. F. Peck, G. H. Blaxter, and H. H. Fairbanks.

Topic, "Underground Circuits." Discussion. C. H. Wilmerding, John A. Seely, H. J. Smith, and M. J. Francisco.

Topic, "How to Rate Arc Lamps." Discussion. James I. Ayer, C. E. Hesser, A. J. De Camp, E. W. Rollins, George R. Stetson, and M. A. Beal. Questions and answers. What is it you Wish to know?

Executive session.

Evening session, 8 o'clock.

Paper, T. Commerford Martin and Luther Stieringer, "Electric Lighting at the World's Fair and Some of Its Lessons." Illustrated with stereopticon.

THURSDAY, MARCH 1, 1894.

Morning session, 10 o'clock.

Paper, Charles F. Scott, "Polyphase Transmission."

Topic, "Arc Lights on Incandescent Circuits." Discussion. C. L. Edgar, L. B. Marks, J. T. Ridgway, W. S. Barstow, Thomas Spencer, John C. Knight, and Frederic Nicholls.

Topic, "Meters vs. Flat Rates." Discussion. Charles E. Scott, J. D. Barth, W. J. Greene, J. J. Burleigh, J. Gwynne, and J. J. Moore.

Topic, "The Alternating Motor." Nikola Tesla.

Afternoon session, 2:30 o'clock.

Executive session.

Reports, secretary and treasurer, executive committee; election.

INSIGNIA.

Officers, red bow; executive committee, blue bow; active members, red ribbon; associate, blue ribbon; guests, olive ribbon; honorary members, white ribbon; reception committee, yellow ribbon.

Storage Batteries.

BY ELIHU THOMSON.

STORAGE batteries or accumulators of many forms during the past ten years have come into my hands for inspection and test, with a view to utilizing them in connection with the electric industries in which the Thomson-Houston and General Electric companies have been directly or indirectly interested. These industries have, as is well known, covered the widest range of electrical application, and the experience gained therein has been of the most varied character. In connection with Mr. Robert Shand, my assistant in this work, very complete tests of each cell submitted have been conducted, and under varying conditions of charge and discharge rates. Special forms of battery have been manufactured by us on a moderate scale and put to use in our work, thus adding the experience of methods of making to that of testing.

With but a few exceptions, storage batteries depend on the formation during charging of spongy or finely divided lead on what is called the negative plate, and of peroxide of lead about the positive plate. In charging, the current passes from the positive to the negative plate in the cell, or electrolyte, and in discharging, from the positive to the negative outside the cell, or on the circuit which is traversed by the current set up in whole or part by the electromotive force of the cell.

It may be useful here to state in a simple way the general character of the reactions which occur in charging and discharging a cell of the ordinary type, or a lead to lead peroxide cell.

Whether the forming process of Plante be used in giving origin to the active material associated with the support or plate from which such active material is derived, or the material be applied in masses to the supporting and conducting plate, either in an active condition or in a condition which is suitable for the formation of the active material itself by the passage of current, makes no difference so far as the reactions themselves be concerned, but may be of vital importance in determining the characteristics of the cell itself, as to durability, economy, capacity, charging rate and discharging rate, etc.

In a charged cell the negative support or conducting plate will have in contact with it a quantity of lead in a metallic yet spongy state, sufficiently coherent to keep its place in the cell and conduct electricity. The positive plate will have, in like manner, in contact with it a quantity of peroxide of lead in a porous state, dark brown in color and in coherent masses—a partial conductor of electricity. These are immersed in the electrolyte of the cell, which is generally dilute sulphuric acid, or solutions of acid sulphate of potassium or sodium, which may be considered to contain free sulphuric acid.

The sulphuric acid is not only essential to the reactions occurring in the cell, but happens also to give to the liquid a very low specific resistance compared with that of many other liquids or electrolytes.

Now the tendency of the acid is to form sulphate of lead both from the spongy lead of the negative plate and from the peroxide on the positive plate. To do this, each molecule of peroxide must lose an atom of oxygen and each atom of the spongy lead gain an atom of oxygen, so as to combine with the sulphuric acid, as here shown.

$$Pb\,O_2 + H_2\,SO_4 = Pb\,SO_4 + H_2\,O + O$$
$$Pb + O + H_2\,SO_4 = Pb\,SO_4 + H_2\,O.$$

or, including the reactions of the two plates in one equation, we have during discharge

$$Pb\,O_2 + Pb + 2\,H_2\,SO_4 = 2\,Pb\,SO_4 + 2\,H_2\,O.$$

The final result of the complete discharge of the cell is then to form sulphate of lead and water, thus removing the sulphuric acid from the electrolyte and forming white sulphate of lead on each plate.

It is not to be supposed that the above simple statement of reactions covers all the changes which the materials undergo. They are doubtless far more complex, but the tendency is to the result stated.

But it is here important to note that the formation of sulphate during discharge is a self-limiting process, and on this self-limitation the possibility of again charging the cell depends. Sulphate of lead is a non-conductor of current. Spongy lead and peroxide are each conductors. But in any given mass of the latter the conductivity will fall as more and more sulphate is produced within that mass, until a further formation of sulphate becomes impossible, owing to the low conductivity of the mixed sulphate and spongy lead, or mixed peroxide and sulphate. It is then "out of the cell," so to speak, for it is only by the passage of an electric current discharge that the formation of sulphate can go on, and as soon as the conductivity is low in any given portion of active material it is not further acted upon, except under a prolonged and, of course, weakened discharge.

So, also, as the nearer portions of active material of each plate, or those most closely held to the support plate or conductor, are the first to be affected and lose their conductivity during discharge, the more remote portions then take a greater and greater part in furnishing the discharge, provided they are not embedded in the other portion, and thus insulated or rendered ineffective. A careful consideration of the above will show why it is that the effective electromotive force of a badly constructed cell will fall rapidly during discharge, while that of a well-constructed cell, with all of its active material closely associated both with the supporting plate and electrolyte, will hold up much better.

It will also be seen to be essential that electric conduction must exist between the active material and the plate, and that the acid must easily reach the active material during discharge or the said material will become virtually inactive through no fault in itself, but merely of its environment.

The gradually falling conductivity of the active material during discharge also explains the fact that the theoretical value of a given amount of peroxide, or of spongy lead, is never to be realized in any cell, for a considerable portion of it only acts the part of a conducting network, so to speak, which carries current to and from those portions or particles which alone are acted on. When the active material is in the form of plugs or masses of considerable size it is necessary that they be made not too compact, or the acid of the electrolyte will not penetrate the blocks, and the capacity of the cell will therefore be very limited. The capacity of a cell may be broadly stated to be dependent on the amount of material which during discharge remains open to the action of the electrolyte, as well as in good conduction to the support plate.

If a cell be discharged below a certain electromotive force, it is liable to be injured by excessive loss of conductivity of the active material due to the conversion of too large a proportion into sulphate, and from the consequent shrinking or swelling and distortion of the material, which may cause it to drop away.

The recharging of such an exhausted cell may be either impossible, owing to the low state of conductivity of the lead compounds, or to the actual rupture of contact with the support plates due to swelling or shrinking, or the charging may require to be carried on very slowly and through a long time to recover the cell as much as possible.

Hence, a battery should never be overdischarged, nor be allowed to rest for a long time in a discharged condition.

The discharged cell is in a weak state, and should be recovered as soon as practicable by recharging, for although a discharged cell left on open circuit may be assumed to remain as it was when the discharge stopped, it in reality is the seat of slow reactions which are in the nature of those occurring during discharge.

The fact that the active material during normal discharge does not become wholly converted into sulphate of lead, but retains conductivity conferred upon it by the presence of peroxide on the one hand and spongy lead on the other, makes it possible to again charge the cell by passing current in the opposite direction, which current thus reaches each part of the active material, decomposes the lead sulphate on both plates, oxidizing the lead compound to peroxide on one and reducing the compound to metallic lead on the other, restoring the conditions before discharge.

Evidently, however, this restoration, to be economical, must be effected at not too high a rate of current. Too high a charging rate will be uneconomical for two reasons. The electrical resistance of the fluid and the plates is highest after discharge, and too large a current in overcoming such resistance converts the electrical energy into heat, and may cause copious evolution of gas long before the cell has received its charge. Even as much as forty to fifty per cent. of the energy of the charging current could be wasted in the case of such cells as have a comparatively high internal resistance by employing too rapid a rate in charging. The most economical rate of charging, so far as the cell itself is concerned, is a very low rate. So in discharge the most economical rate is a low rate. A very high rate of discharge, while liable to injure the cell by disintegration, is objectionable also from the standpoint of economy, as the efficiency of the discharge may then be very small.

The curious fact of the recovery, on standing after partial discharge, of nearly the full electromotive force is easily explained when one considers that the contact of the acid is requisite to discharge. During a fair rate of discharge there will be some parts of the active material which are not so freely reached by the acid as to be so fully discharged as others. They will then only exhaust the acid already soaked into their pores, and stop discharging when this acid is exhausted, though the material itself remains highly active. On standing, by osmosis, new acid diffuses into contact with such material and confers, of course, renewed activity for a short discharge, or one made at low rate. This recovery action may be repeated a number of times before the cell fails.

From this it may be seen also that a small current rate, in discharging, will be kept up for a much longer proportionate time than a large rate, for the reason that more of the active material is used in the former case, while, of course, in addition the electromotive force at the cell terminals is always higher with the smaller rate of discharge.

Of the various forms of battery tested by us, we found that none of such types as departed from the lead to lead peroxide in sulphuric acid type gave results in any respect superior to the latter; and, in fact, our experience has taught that the best forms of the latter do not differ among themselves very much in their merits, notwithstanding variations in methods of preparation.

The user is, of course, more interested in the working of the cell than in the various details of the manufacture. In general, the Brush type, with lead compounds applied to conducting grids or supports, has been found better than the Plante types, in which the lead compounds have been formed by a more or less tedious process of disintegration from the plate itself.

Neither can it be said of any particular make or form of battery or plate that it is best for all conditions of use. High capacity for a small weight seems to be inconsistent with great durability. High charging and discharging rates are inconsistent with great economy; and so it goes, the special feature demanded must determine the type of cell to be used.

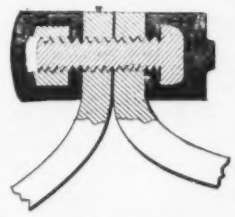
The greatest disadvantage met in the use of storage batteries is the fact that the cells require watching or constant inspection to detect any incipient weakness or short circuit indicated by the voltage of the cell being too low.

In such case, it is essential that the cause of the difficulty be at once found and removed and the cell be carefully brought to a condition of full charge. A cell that has become short circuited and has remained so for some time is either ruined or can only be restored by careful charging at a low rate continued for a long time.

It is well to have the connections of a series of cells made so that any faulty cell can easily be disconnected, and, if need be, removed from the set. Where the terminals are soldered or melted together, this is not easy, but if the cells could be relied upon to give no trouble, it undoubtedly would be the best way to make the connections.

If the connections be made by the use of copper or brass bolts binding the lugs or clamping them, trouble is frequent on account of the corrosion of the metal of the clamps by the acid spray and by the creeping of the acid to the joint. Silver plating the brass or copper pieces is a great assistance in avoiding corrosion, and, in fact, instruments having exposed baser metal should have the metal surfaces silver plated or gilded if they are to be used near storage batteries undergoing charge.

A good way of making connections of the lugs of the cells is to employ a bolt of silver plated brass with a cap nut, both bolt and nut being covered all over, except the thread, with hard rubber, as also the faces of nut and bolt which bear on the lead lugs. In making a joint with this connector the thread is to be covered with a grease or oil, such as vaseline, and the cleaned surfaces of lugs where they meet may be likewise coated before screwing the parts together as in the figure. The oil or vaseline is effective in keeping the acid out of the joint, and the joint may be broken at any time and renewed with equal ease. With such provision the removal or replacement of a cell is easily accomplished. "A stitch in time saves nine" is a saying which will apply forcibly in storage battery work, and it is safe to say that if the attention given to them is based on such a principle, there are several forms of storage battery which, for stationary use, will cost but little for maintenance if the service required of them be well within the limits of capacity and rates of charge and discharge set for them.



Whether or not they can be employed in any given case in connection with station work with continuous currents is a question which cannot be answered generally. The particular conditions of use would need to be carefully considered and estimates of cost of working with and without storage made, so as to determine the relative economy of each plan before deciding on the introduction or non-introduction of the storage plan in an installation. Each case is a problem by itself and should be solved as such. For traction work, such as furnishing current for electric cars, the experience hitherto has not been in favor of storage batteries, either from the standpoint of economy or technical adaptability. This has been the case even under favorable conditions of grades, etc., and it is therefore hardly to be expected that under the harsh conditions imposed in most of the street railway service the storage battery car could compete with the system of direct supply of current.

Who Invented the Rotary Field Motor and Biphase System of Power Distribution?

BY LIEUT. F. JARVIS PATTEN.

THE above question may seem like heresy now that six years have passed since the rotary field motor was brought to the attention of the electrical public. Though it was then received with undisguised admiration, and practical machines were exhibited in operation at the time, still this admiration was not unmixed with wonder as to whether the thing was really any good or not.

For a long time there existed general apprehension that this unique conception might be simply a beautiful theory without a practical side to it. At that time also electrical engineers were struggling with the difficulties of direct-current machines and earnestly wishing that a motor could be found without a troublesome commutator and brushes.

When, however, this much-desired result was shown, they did not quite like it, after all; it did not look quite right, somehow, and that sort of skepticism and doubt arose that ever attends the announcement of anything unexpectedly novel; it is the old story of the world's inventions. In this country the invention was almost forgotten for a few years, until it again blossomed out in Europe, dressed in a more finished form. Then the skeptics began to realize that this invention had come to stay, and had some work to do in the world. Then discussions arose as to who invented it that have not yet been settled to the satisfaction of all concerned, and many inventors began to improve and change it, calling the change or improvements independent inventions having no relation to the broad conception before announced.

That is the way with most good things the world wants done and offers a prize for. The inventor presents his solution and the world says: "We cannot quite believe you now. That is ingenious, very, but it isn't quite the thing we want."

Then the time comes when it is found to be the thing, and it is accepted by sheer force of merit, and the world then says: "Yes, it is a good thing, after all; but it's old. Smith

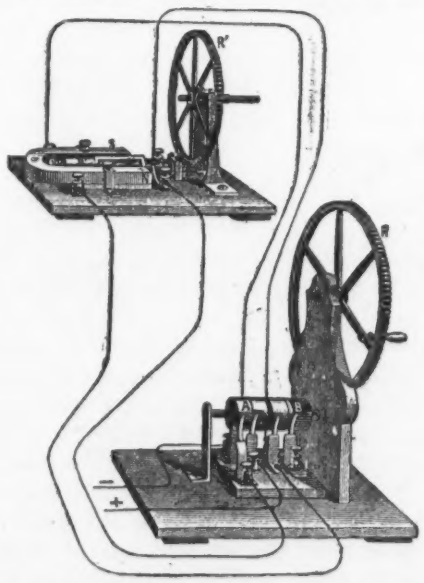


FIG. 1.—DEPREZ ROTARY FIELD MOTOR.

made it years before he died, and it belongs to us now if it belongs to anybody."

The plausible claims to the invention of the rotary field motor, whether actually asserted by the inventors or not, are historically interesting. Let us examine a few of them and see what they amount to. The first mention of a rotary field in the records to which I have access is found in the "Philosophical Magazine" for October, 1879, where Mr. Walter Baily in a short article shows how to obtain a rotating field effect by shifting a battery current by means of a commutator to different pairs of magnet poles in rotation. These magnets, acting upon a copper disc, the surface of which is in close proximity to the poles of the magnets, caused it to revolve. We have here an instance of a shifting field and very crude form of a rotary field motor.

The first thing shown, however, that I can construe as the equivalent of the rotary field motor, as shown in its simplest form by Mr. Tesla in 1888, is a very interesting device produced by Marcel Deprez and operated by him in 1880.

A perspective view of this apparatus is shown in Fig. 1. It is called a synchronous motor, and is described in "La Lumiere Electrique" of that time simply as a machine for

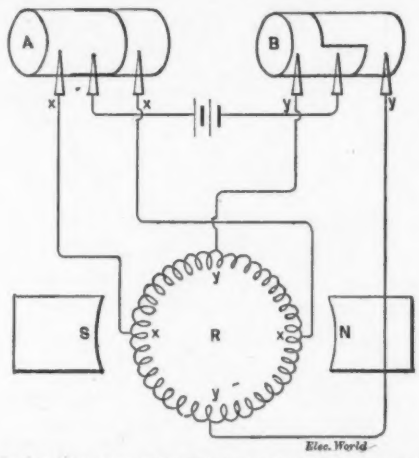


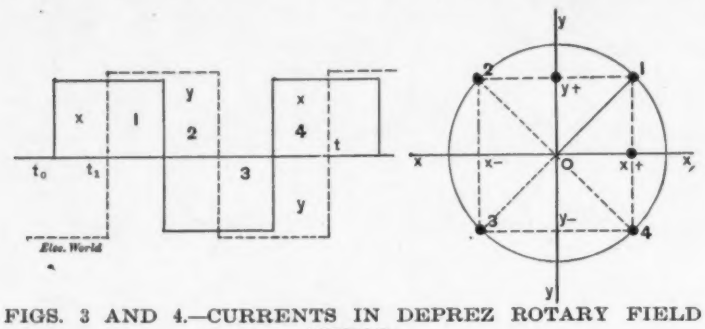
FIG. 2.—DIAGRAM OF DEPREZ ROTARY FIELD MOTOR.

effecting the synchronous rotation of two spindles placed at a distance from each other, as indicated by the figure.

The wheel *R* of one machine is turned by hand, or other power, and drives two commutators, *A* and *B*, that are carried by the driven spindle. The commutators are simply two part current reversers and the two segments of both are connected to four separate contact rings. Direct current from a battery, or like source, is led to brushes that bear on the commutator segments, while four other brushes that bear on the rings are connected to leads that go to brushes bearing on four rings of the distant motor. To each pair of these motor rings are connected the terminals of a single coil Siemens armature, the two being fixed at right angles to each other on the spindle of the motor and placed in a two-pole field, indicated in the figure by the permanent magnet *N S*. Under these conditions this double armature of the machine *R* moves in perfect synchronism with the commutator of the near-by machine *R*, when driven forward or backward by the hand or otherwise.

The operation of this device—the driven motor of which bears so striking a resemblance to a two-phase rotary field or Tesla machine—will be better understood by reference to the diagram of operative parts shown in Fig. 2, where, for sake of comparison, the armature of the driven motor is shown as a ring winding, with the operative circuits connected to the extremities of two diameters at right angles to each other, which amounts, in fact, to the same thing as the other arrangement. *A* and *B* are the two commutators and four rings of the driving machine; they correspond in effect to the two-phase generator, or source of supply, in such a system of power distribution. The dividing planes of the commutator segments are at right angles to each other, as shown, while all the brushes are on the same line, from which arrangement it results that the two currents in the circuits *X X* and *Y Y* are interrupted and reversed intermittently, producing the

two reversed currents shown in Fig. 3, where the heavy line *X X* represents the current in one of the motor circuits, and the broken line *Y Y* is the current in the other during a single revolution of the commutator spindle. These currents, therefore, when referred to the same time line as in Fig. 3, appear as two continuously reversed, or alternating, currents in quadrature relation, and are, in fact, a particular case of such currents just as much as are those represented by the two sine curves similarly superposed in Fig. 5, the only difference being that the latter follow a law of constant change, while the former do not. We may, therefore,



FIGS. 3 AND 4.—CURRENTS IN DEPREZ ROTARY FIELD MOTOR.

consider the motor in this case supplied by two-phase reversed currents in quadrature with each other.

So far the resemblance to a rotary field motor operated by two-phased alternating currents is certainly very close, but here the resemblance ceases, for, upon examination, we shall find that these intermittently reversed currents cannot produce a true rotary field effect in the armature circuits of the motor, as would two alternating currents of the sine or continuously changing form under the same circumstances.

In Fig. 4 is plotted the successive effects of these currents in the armature *R* as they successively occur during the periods 1, 2, 3, 4, Fig 3, of a complete revolution of the commutators. During period 1 we have both the *x* and *y* currents positive in direction and equal in strength, giving a resultant magnetization, 01, Fig. 4, which represents the successive magnetizations of the armature ring *R*. Then we have *y* positive and *x* negative and both equal again, giving the resultant 02, and in a complete revolution we have four successive polarities in as many different positions around the ring; and it is important to bear in mind that each polarity in turn remains fixed in direction for a certain time, when it ceases and the next begins in a new position a quarter turn further on, and there is no movement of the polar line between two successive positions. In other words, the polarity of the ring, in this instance, jumps from one quadrant of the ring to the next in turn, and this is not a true rotary field effect like that produced by two sine currents in the same circuits, for such currents produce a polarity that remains constant and moves uniformly from point to point around the ring, as in Fig. 6. The latter is the true rotary field effect, and the only known way of producing it

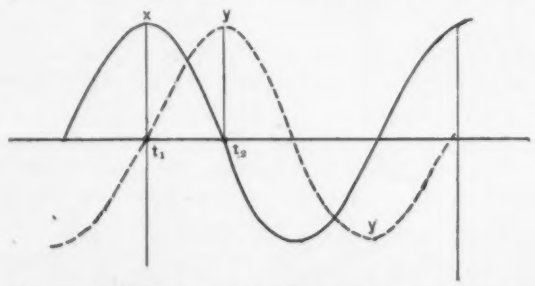


FIG. 5.—CURRENTS IN MODERN ROTARY FIELD MOTORS.

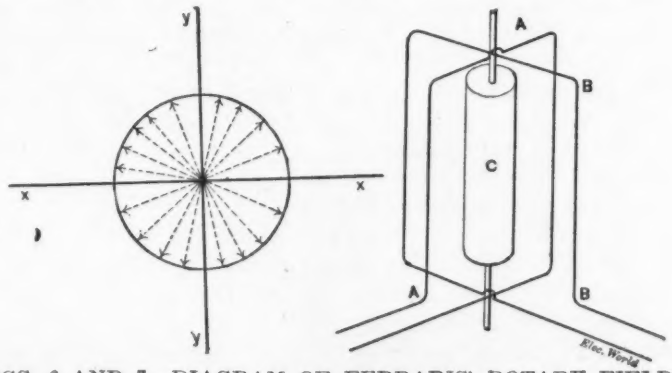
was first enunciated by Professor Ferraris in 1887 in a description of what he termed "electrodynamic rotation," wherein he explaines that a progressively shifting rotary field is produced by the introduction of two continuously changing alternating currents into two coils fixed in planes at right angles to each other, as indicated in Fig. 7, which shows two such coils, *A* and *B*, in vertical planes at right angles to each other, with a cylinder of copper, *C*, free to move about a vertical axis, which coincides in position with the line of intersection of the planes of the coils. Two continuously varying alternating currents of the same frequency, Fig. 5, being sent through each of the coils *A* and *B*, the copper cylinder *C* is set in rotation about its axis. Each coil by itself produces an oscillating magnetic field, due to its own reversing current, the lines of force of which are at right angles to the face of the coil, and the two coils acting together produce a resultant field that turns continuously around the vertical axis of the apparatus. Note that here the field is not alternating in the plane of one coil and then in the other at right angles to it, as in the Deprez machine, but is moving progressively around the entire circle.

The description and apparatus were elementary, but the enunciation was broad and fundamental and bears the true stamp of discovery. The principle thus stated by him and given to the world underlies every practical rotary field motor to-day.

Following closely upon the enunciation of this principle by the Italian professor came Mr. Tesla's announcement of his invention of the rotary field motor in May, 1888, while during the winter of '87 and '88 he had constructed a number of practical machines, and he was certainly the first to bring an application of the true rotary field principle to practical form.

The Deprez machine was not an application of the true rotary field effect, while Tesla's first machine was, and his broadest patent claims are directed to this effect.

Mr. Tesla also clearly showed at the same time the triphase and multiphase rotary field, so that it is hard to see



FIGS. 6 AND 7.—DIAGRAM OF FERRARIS' ROTARY FIELD MOTOR.

how any variation depending upon the use of three or more currents can be claimed by later inventors, as I understand it has been.

While, however, Deprez did not show or use a true rotary field and did not show a practical method of operating motors by multiphase currents, because the method he described is not really suited to a system of power transmission, still it is interesting to note that the motor he showed is in every sense a rotary field machine, having all the essential elements of such a machine, and requires only to be supplied with true alternating currents in quadrature to act as such. The Deprez motor is a simple form of Tesla motor; the system of distribution is different and defective, and as this is the only difference that separates the two, it leads us to the question, "Who first used multiphase or biphase currents?"

Who first used the method of supply that would have made the Deprez invention a clear anticipation of the Tesla invention in all its essential features? It would require the

search of records not now at my command to answer this question definitely, but it was certainly not Tesla, and apparently neither Ferraris nor Deprez, for I find mention of biphase currents in connection with arc lighting more than twenty years ago. The Haselwander dynamo, a triphase generator, antedates the Ferraris and Tesla inventions, so it may be assumed that Tesla was using a previously known method of supply in 1887 that made all the operative difference between his machine and the Deprez machine. Thus, the method of supply which would have made a true rotary field motor of the Deprez machine was a well-known one at the time, and had such a system of distribution been applied to the Deprez machine, it would have constituted a broad and complete anticipation of both the Ferraris discovery and the Tesla invention.

The Tesla motor had its complete parallel in the electromechanical contrivance of Deprez; it only needed the biphase currents used by Jablochkoff years before. The long separation of these two elements, both known and both necessary requisites to a simple and useful combination, is a pertinent illustration of how slow invention really moves even in the nineteenth century. There were years during which the application of then known biphase currents to a machine of the Deprez type, also well known, would have brought the true rotary field motor to public notice.

I am aware that it is almost splitting hairs to say that the system of supply given by Deprez to his machine is not a true biphase system of distribution; many would contend, and perhaps justly so that it is. It may be contended that a rotary field that makes four jumps in a revolution and might make any number short of actual infinity is just as much a true rotary field as one that actually does make an infinite number, and I am not prepared to say definitely that it is not. Then, again, if the currents of the Deprez apparatus are rounded off by self-induction, we would then have a true rotary field indeed.

No sooner, however, had the real value of the Tesla machine become an accepted fact than it was turned and changed from one form to another, all involving the Ferraris principle applied in a slightly different way, and being explained upon principles of induction and varying magnetic flux gave their inventors foundation enough to claim the rotary field motor as their own.

In view of the fact, however, that the Deprez motor, open to the public, has all the essential elements of a rotary field motor, for the permanent magnet may well represent a closed-circuit field winding, and that biphase current generation and distribution are not broadly patented, are not, then, the rotary field motor and biphase-current power distribution also open to the public?

Take, for instance, the Niagara plant, in which two separate alternating currents are to be generated in quadrature relation and sent to consumers on two independent circuits for use singly or in conjunction with each other, why may not a motor of the Deprez type, public property for fourteen years, be connected to the four mains without infringement of patent rights? Such an instance would be a true rotary field motor operated by a biphase system of power distribution.

In conclusion it would seem that no single inventor can claim broadly very much of a complete system of power distribution by means of biphase alternating currents and some form of rotary field machine.

Not an Admirer of Mathematics.

Galileo is reported to have said that he was very glad that he devoted only two years of his life to mathematics and the rest of it to physics.

Parallel Running of Alternators.

BY CHAS. PROTEUS STEINMETZ.

THE practice in continuous-current circuits from the beginning has been to run all the generators in parallel on the same bus bars.

The same has been done abroad in alternating-current circuits. For instance, on the Continent the Ganz & Co. machines are running in parallel, or in synchronism.

In this country parallel running of alternators has not found an extensive application, and frequently even the opinion has been expressed that the machines built in this country are not suitable for parallel working.

The result was that larger alternating-current stations have been built with a very elaborate system of switchboards, crossovers, etc., so as to avoid parallel running, and the service, as a result hereof, is not always very satisfactory.

To settle this question of parallel running of alternators, I made an exhaustive investigation of the subject, of which a few results may be of interest:

First—We may discard all the usual theoretical statements on parallel working relating to the effect of frequency, self-induction, etc., as wholly disproved by experience.

The use of artificial loads and sundry such relics of past ages of engineering, to assist in getting machines in step, are to-day hardly to be considered seriously.

With regard to frequency, I investigated experimentally the parallel working of alternators of a frequency as high as 125 cycles and of a frequency as low as 25 cycles per second, and found no difference whatever, and at the high frequency, as well as at very low frequencies, machines properly designed for these frequencies work perfectly in synchronism.

The self-induction of machines within the limits met in well-designed alternators has nothing to do with the success of synchronous running, and I had three phasers of very low armature self-induction running in parallel with each other and ironclad single phasers of high armature self-induction.

The theoretical conclusion that the condition of best synchronous running is a lag of 45 degrees in the alternating-current circuit, is, as probably generally known now, based on an error in its premises; that is, on a mistake of the external circuit for the cross-circuit between the two armatures. Corrected, this reasoning would mean that the armature inductance shall equal the armature resistance for best synchronous working. This condition is impracticable in commercial alternators, and would, if fulfilled, rather give the condition of a very unsuccessful parallel working.

As known, Mordey succeeded in running a 1,000-volt alternator in parallel with a 2,000-volt alternator. To show how far equality of potential of machines is necessary for parallel running, I made, amongst others, the following experiments:

Two 60-kw. ironclad high-frequency alternators, General Electric Company's standard machines, were driven at their normal speed, corresponding to 125 cycles per second. The fields of these machines were excited so as to give 1,000 volts at the terminals of each machine, and then without any further precautions both alternators were thrown in parallel, directly dropped into step and ran in synchronism with an interchange of current between both machines of 4 amperes only.

Then the experiment was repeated, but the voltage of one machine brought to 1,100 and that of the other to 900, so as to have a difference of 200 volts between the poten-

tials of the machines, and then the machines thrown in parallel.

The cross-current was slightly increased to 6.5 amperes, but the machines ran in parallel just the same. In this way gradually, in each following test, the voltage of one machine was increased and that of the other reduced by 100 volts, until at last the one machine was excited up to 2,000 volts, the other was left entirely unexcited at 0 volts, and both machines thrown in parallel, with a difference of potential of 2,000 volts. Still the machines ran in parallel, in this case with a considerable cross-current, however.

In the attached table and diagram the behavior of the two machines is shown when thrown in synchronism at the various potentials. As abscissae are given the differences between the potentials of the machines before throwing them in parallelism. The inclined lines I. and II. are the voltages of the machines before thrown in parallel; the line III. is the voltage at the common terminals of the machines after synchronizing. As seen, up to about 1,000 volts difference of potential between the machines, the resultant voltage is the average between the individual voltages of the machines. At a greater difference of potential the resultant voltage is somewhat higher, due to the approach of saturation in the first machine.

SYNCHRONOUS RUNNING OF TWO HIGH-FREQUENCY IRONCLAD ALTERNATORS.

60 Kw. 125 Cycles.

E. M. F. of first alternator, before synchronizing.	E. M. F. of second alternator, before synchronizing.	Difference of the E. M. Fs. of the two machines, before synchronizing.	E. M. F. at the common terminals of both machines, after synchronizing.	Interchange of current between machines, after synchronizing.	Excess of momentary current at the instant of synchronizing over the cross current.
Volts.	Volts.	Volts.	Volts.	Amperes.	Amperes.
1,000	1,000	0	996	4.0	2.0
1,100	900	200	1,000	6.5	.5
1,200	800	400	1,000	13.0	3.0
1,300	700	600	1,000	18.0	4.0
1,400	600	800	1,026	24.0	6.0
1,500	500	1,000	1,010	28.0	6.0
1,600	400	1,200	1,040	39.0	3.0
1,700	300	1,400	1,046	44.0	5.0
1,800	200	1,600	1,060	50.0	6.0
1,900	100	1,800	1,066	56.5	5.5
1,000	0	2,000	1,075 ± 70	62.0	10.0
Full load current.....				25.0	

When the excitation of the second machine is brought down below 100 volts, while that of the other approaches 2,000 volts, the resultant voltage begins to get unstable and fluctuates about ± 70 volts; that is, the limit of synchronizing power of the machines was approached, and the machines alternately tend to drop out of step, and are brought back into synchronism again.

The curve IV. gives the cross-current flowing between the machines. Since 52 amperes is the full-load current, the interchange of currents between the machines reaches the full load value at a difference of potential of about 1,650 volts between the two machines.

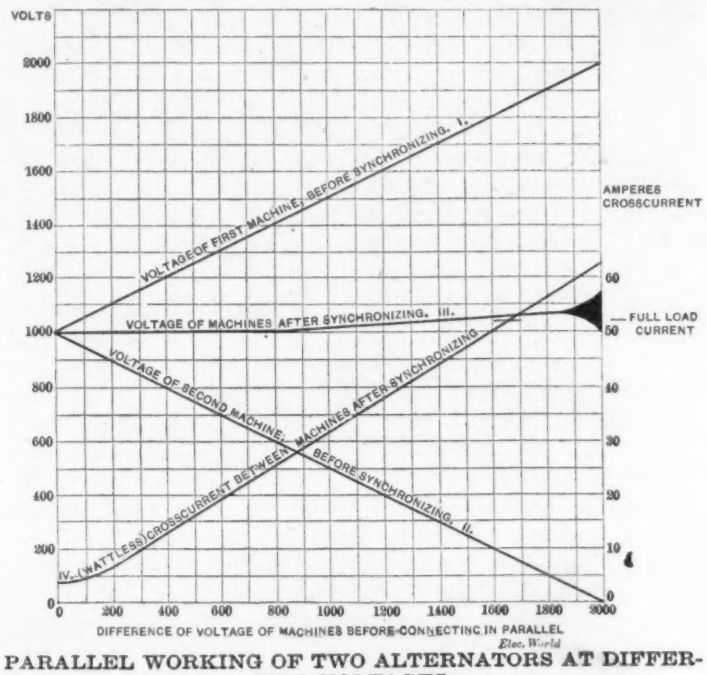
This cross-current is obviously essentially a wattless current. To determine the momentary rush of current in the moment of throwing the machines in synchronism, a phase lamp was connected in and

First—The sychronizing switch closed at the moment when the machines were in phase with each other.

In this case the momentary throw of current was from 0.5 to 6 amperes in excess of the stationary cross-current, according to the care of adjusting for equality of phase, or, in other words, by adjusting the machines to an equality of phase when throwing them in parallel, an instantaneous rush of current is entirely avoided.

Second—The synchronizing switch was closed at the moment when both machines were just in opposition with each other, so as to short-circuit one of the machines by the other; then an instantaneous rush of current passed through the machines, which, however, subsided in a small fraction of a second, and the machine settled down into step.

The conclusions drawn from these and other tests are in complete agreement with the theory that with properly designed alternators, parallel running is perfectly successful, even under very extreme conditions of load and excitation, and no special or careful adjustment is required to throw two alternators which run at the same frequency into parallelism.



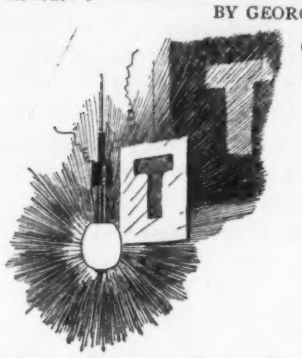
PARALLEL WORKING OF TWO ALTERNATORS AT DIFFERENT VOLTAGES.

"Electricians in England Have Everything to Learn from America."

Mr. Preece, who was credited with having made the remark that "electricians in England had nothing to learn from America," refers to that supposed remark in the following terms in the conclusion of his recent interesting paper on his trip to the United States: "Interviewing is a feature of American journalism that, thank goodness, has not taken root here. I was surprised to read of interviews with myself, extending to two or three columns, that resulted from the passage of a few compliments; but I was more surprised to find that statements supposed to have been made by me to an interviewer were taken *en serieux*. One irate functionary compared an official statement of our postmaster general with a mythical statement made by me and triumphantly pointed out such a glaring contradiction as a complete refutation of my fallacies. I even read that we electricians in England had nothing to learn from America. I have no recollection of ever having made any remark which could by any shorthand blundering have been construed into such an absurdity; but if I had done so, it would more likely have been one where 'nothing' was a telegraphic error for 'everything.' I cannot too gratefully speak of the attention and kindness I received from every one, and I certainly feel that I have personally profited from my visit very much indeed. A visit to the United States is something like charging an accumulator. It stores the visitor with energy. When I am discharged and my adverse criticisms are forgotten, I shall probably cross the Atlantic again."

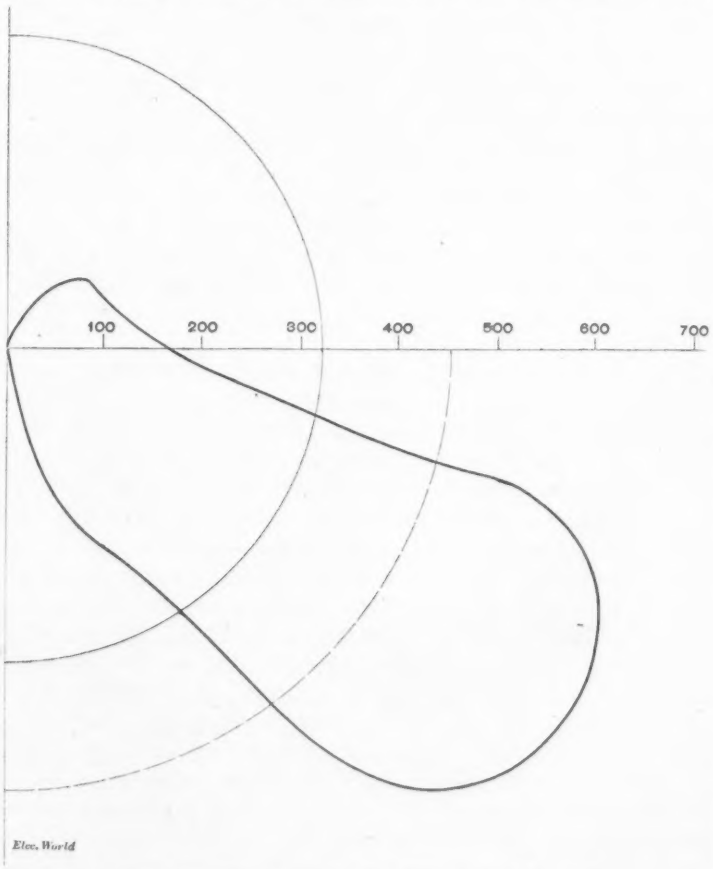
The Loss of Light from the Use of Globes with Arc Lamps.

BY GEORGE D. SHEPARDSON.



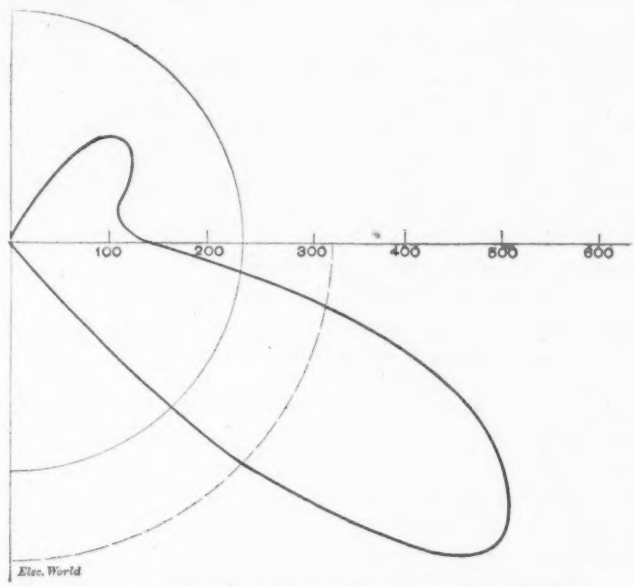
To the investigator, whether he be a student in the laboratory searching for new truths, or whether he be in charge of a central station or isolated plant, arc lighting presents many interesting problems. A renewal of interest in this important subject seems to have been arising during the past two or three years. The choice of dynamos, lamp mechanism, the size, shape and quality of carbons have been receiving a considerable amount of attention. Some thought also seems to have been given to the subject of globes. The importance of keeping these clean has long been recognized, but comparatively little attention seems to have been paid to the relative efficiency and desirability of different kinds.

Believing the subject of arc lamp globes to be a fruitful field for investigation, Messrs. J. D. Guthrie and F. E. Reidhead, two of the seniors in the department of electrical engineering in the University of Minnesota, arranged a photometer for measuring the intensity and distribution of the light from an arc lamp with various globes and without any globe. In order to measure the light at different angles above and below the horizontal plane, the lamp was suspended from the end of a frame which could be rotated about



CANDLE POWER CURVE WITH BARE ARC.

an axis parallel to the photometer bar. A rotating mirror was placed on the photometer bar in such a position that by adjusting the mirror and the arm that carried the lamp the light in any direction from the arc would be reflected along the photometer bar, where it could be measured by a Bunsen photometer. The principal point of difference between this device and that usually found in laboratories for similar purposes is that the adjustable mirror was about 16 inches in diameter. The reason for having so large a mirror was that the photometer might measure the light radiated from all parts of the globe and not merely that from the arc. A 16-c. p. 50-volt lamp was used as a standard, having been previously calibrated with great care. The Bunsen disc, with grease spot, gave fairly satisfactory readings of candle power after some practice. The arc lamp used was the Thomson-Houston ribbon feed type, adjusted to keep the potential as constant as possible. Current was supplied by a Thomson-Houston arc machine, regulated for 6.85 amperes. The standard incandescent lamp was shunted around a wire re-



CANDLE POWER CURVE WITH CLEAR GLASS GLOBE.

sistance in series with the arc lamp. This was found to give a very steady and satisfactory light. The potential around the arc lamp and the incandescent was measured by means of a standard voltmeter and a double-throw switch. The current was measured by an ammeter previously calibrated.

The photometer was arranged so that the standard lamp might be moved in order to keep the car at a sensitive position on the bar. For some readings it was necessary to use the original standard of one candle power. Reflection from the floor and walls was prevented by placing between the arc lamp and the car a large screen, through which a hole about one foot in diameter allowed the direct light to pass while cutting off all extraneous light. The plentiful use of dull black tailor's pattern paper reduced the stray light to a minimum.

Having taken these precautions, the light from the arc was measured in different directions,

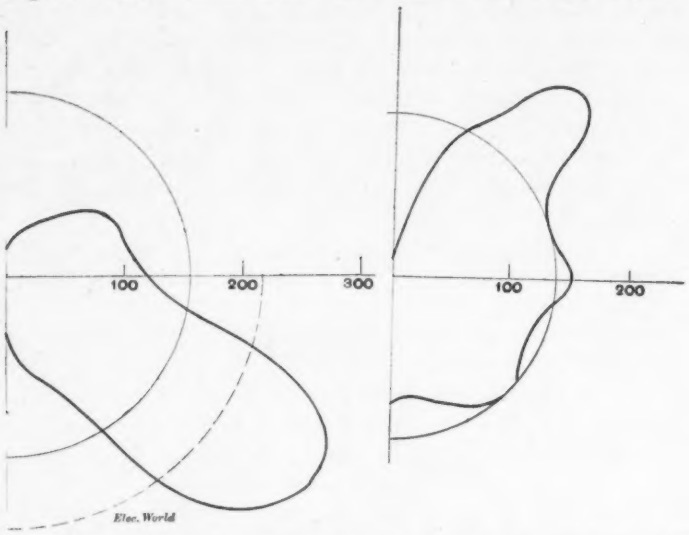
(*a*) with no globe,
(*b*) with a clear glass globe,
(*c*) with a ground glass globe,
(*d*) with an opal, or white, globe.

The average of ten readings of candle power for each position is given in the following table of results:

Direction.	Candle Power. Bare arc.	Clear glass.	Ground glass.	Opal glass.
90° below	0	17	45	109
75° below	126	9	90	104
60° below	262	22	141	128
45° below	641	313	286	141
30° below	681	580	314	130
15° below	498	408	199	126
Horizontal	153	132	115	154
15° above	120	107	106	141
30° above	107	145	102	145
45° above	101	155	73	226
60° above	37	53	48	151
75° above	28	9	35	81
90° above	0	8	8	19
Mean spherical candle power	319	235	160	144
Mean hemispherical candle power	450	326	215	(138)
Average voltage	53.6	50.1	49.0	49.4
Per cent. spherical efficiency	100	53	53	19
Per cent. efficiency at maximum	100	82	47	(33) 16

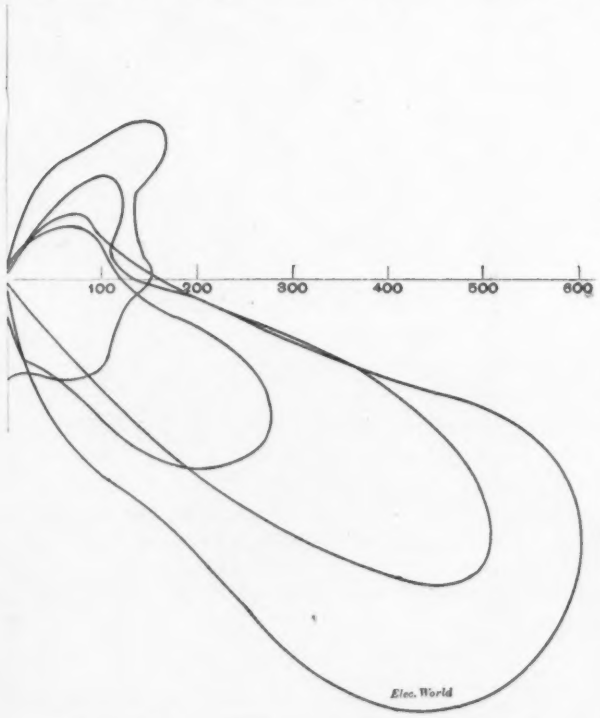
These figures are not exactly comparable, because the voltage was somewhat different for some cause not determined.

For obtaining the "mean spherical candle power," curves were plotted, showing the intensity of the light at various angles. The area of each curve was measured by a planimeter and a circle of equal area was drawn. The radius of this circle gives the value of the candle power if the light were equally distributed in all directions. Since, however, in most arc lighting the downward light only is used, or principally so, it is preferable to obtain the "mean hemispherical candle power," or the equivalent value of the light, if equally distributed in all directions below the horizontal. This latter statement would, of course, be modified in the case of interior lighting, especially if opal globes are used, or if the arcs are inverted so as to light by reflection from ceilings and walls.



CANDLE POWER CURVES WITH GROUND GLASS AND OPAL GLOBES.

The amount of light transmitted by the different globes is given in percentages of the total amount given by the bare arc. The globes tested were obtained from the local lighting company through the courtesy of the secretary and manager, Mr. A. M. Robertson. These were taken from stock without any care to select good or poor ones.



CANDLE POWER CURVES ASSEMBLED.

The results of the test show that the amount of light absorbed by globes is no inconsiderable quantity. It is expected that this investigation will continue in order to determine the best kinds of glass to use, comparing various makes now on the market, and other problems. Interesting results are to be expected from a study of interior illumination by inverted arcs with and without metallic reflectors.

The above is to be considered only as a preliminary report of investigations upon an interesting and somewhat complicated problem.

Boilers for Small Central Stations.

BY REGINALD A. FESSENDEN.

IT is a sufficiently difficult matter to design a large central station so that it shall give good results as regards economy in running, in labor, and as regards ease of extension. Smaller stations, however, it is generally admitted, call for far more exercise of ingenuity. Though the great majority of those qualified to speak on the subject have preferred to retain their experience for themselves, certain facts are well understood.

Such are, for instance, the necessity of choosing machines having an efficiency characteristic shaped with regard to the work to be done, or choosing units such that the machines shall always be working nearly at full load, and so that the reserve of power may be as small a percentage of the total power as possible, and of selecting machines capable of standing a considerable percentage of overload without undue heating, so that the different combinations of units may overlap one another.

In passing the writer may say in regard to the second subject—the choice of proper units—that the plan followed in some large central stations, where a number of machines are run in parallel, of using units in geometric ratio, i. e., of powers in the ratio, 1, 2, 4, 8, 16, etc., does not appear to be the best. In the first place the ratio of reserve to total power must be too great, and, secondly, too many spare parts must be carried in stock. A better method would appear to be what might be called the triple unit method (used with dynamos capable of standing 30 per cent. of overload for considerable times). In this system, if the lowest load were one-sixteenth of the maximum, the units used (with due regard to maker's standard sizes) would be in the ratio 1 — 2 — 4 — 4 — 4. The next addition would be an 8 unit, then two more 8s, a 16 and so on up, the final plant being 1 — 2 — 4 — 4 — 4 — 8 — 8 — 8 — 16 — 16 — 16 — 32, etc., the smaller sizes being, of course, discarded as the size of the station increased. It is believed that this system gives the best combinations as regards efficient running, and requires least percentage of reserve power, or of extra parts.

With regard to the boiler plant, however, not so much has been written. With the exception of the plan proposed by Mr. Raworth, and which has the inconvenience of requiring a distributing box for the exhaust steam, and pipes leading from it to half the tubes of the boiler, the writer is not aware of any attempts to prevent waste in this direction.

What the amount of this waste is may be shown from the following figures: On the average, a boiler will contain, with the water near the lowest gauge, from 60 to 120 pounds of water per horse power of rating (at 100 pounds pressure), the lower amount being for boilers of the marine type and the larger amount for water-tube boilers.

It is easily calculated that on closing down a boiler with 60 pounds of water per rated horse power no less than 5-h. p. hours are left in it in the heated water per horse power of rating, so that for a 100-h. p. boiler the total amount wasted would be 500-h. p. hours.

If, then, we start up a 100-h. p. boiler at 6 P. M. and run it till 9 P. M. at its full rated capacity, we leave in it nearly twice as much energy as it has supplied. It is true that the water may have been supplied from a feed-water heater, but ultimately the heat comes from the coal pile, and is wasted.

The most obvious means of lessening the waste is to use a boiler having less water capacity. Unfortunately, while this is all right where the load is constant, as on board ship, it will not answer with an electric light or power plant. Here the changes of load are so sudden that the steam pressure would fluctuate so much as to render the use of such a boiler impracticable.

This is upon the supposition that the draught of the grates is due to a tall chimney. Until lately this was the only means, if we except forced draughts from pressure in the stoke-hole. Thanks to the coking arch and the mechanical stoker, it is now possible to use short chimneys with power-driven exhaust fans. This also enables us to use fuel economizers. It would therefore seem as if, under these circumstances, a boiler having smaller water capacity might be used. If the power (electrical or steam) used to drive the exhaust fan were worked by a regulator, so as to speed up instantaneously upon the smallest fall in pressure, it is possible that good results could be obtained. With such a system, and the use of a fuel economizer, it would appear, theoretically at least, as if at least half the coal might be saved in the running of small central stations.

An idea of the type of boiler meant may be obtained from the following description of a boiler used by Mr. Maxim, which the writer had the pleasure of seeing in the former's workshop in Kent. This boiler, it may be remembered, is the one by means of which Mr. Maxim solved the problem of generating power for aerial navigation; the total weight of boiler, engines, condenser, water and oil supply, casing and supports for boilers being only 13 1-2 pounds per horse power, and 1 h. p. being able to lift 180 lbs.

The total weight of the boiler tubes is only 1 pound per horse power. Connecters, supports, etc., bring the total weight per horse power up to 3 pounds. This shows that the amount of heat necessary to heat the boiler fittings is very small.

The important point, however, in connection with our present subject is that instead of using 100 pounds of water in the boiler per horse power, the total weight of water in circulation in condenser, boiler and connections is less than 1 pound per horse power. Such a boiler can be started up in a few seconds, and on stopping the loss of heat would be negligible, less than 1 per cent. of that of present practice.

Mr. Maxim has never made any secret in regard to the construction of this wonderful piece of apparatus, and has published some of these figures in his papers in the periodicals, but the following particulars have not been given before, and may be of interest. (A general idea of the boiler may be got from the cut of the boilers of the Speedy, given in the "Scientific American Supplement," Dec. 16, 1893, or in the London " Engineer." The principal difference between Mr. Maxim's boiler and the cut is the replacement of the fire-box, etc., by a gas burner, and the use of small copper tubes, instead of iron.) No walls or casings are used, the only protection against radiation being a single sheet of asbestos laid over the outside tubes. The efficiency of the water-tube arrangement is so remarkable that under full steam the varnish on the smoke-stack (if it can be called so when there is no smoke) is not even charred. To make a rough estimate, considering the small size of the boiler for its rated capacity, 400 h. p., the efficiency must rise at least into the nineties.

The tubes used are of copper, about 1-4 inch diameter (all joints brazed), and the water is driven through them with great velocity, and flashed into steam immediately after passing through one short section of tubing. The fuel used is a gas from light petroleum.

Now, it is not meant, of course, that such a boiler should be used in central stations, but it is merely given as an example of what can be done in the way of boiler making. The general principles for an economical boiler (not a boiler which is economical when run for a long time and steadily, but one which is economical under such conditions as are found in actual electric light and power stations) would seem to be as follows:

1. The use of an exhaust fan for draught, the velocity of the fan being governed by a regulator working through change of boiler pressure.

2. The use of small water tubes in conjunction with forced water circulation.

3. The use of a substance as fuel which is capable of combustion at a more rapid rate than coal is in its ordinary state. It is quite possible that coal (which, as is well known, forms an explosive mixture with air when in the form of dust) in the form of very fine powder could be used with an atomizer working with a screw feed.

4. The arrangement of the water tubes so that there is no necessity for brick walls, etc., the only material heated outside the boiler being a thin heat-insulating covering.

Should it prove possible to design such boilers, there is no doubt but that there would be a very considerable saving in their use over those of the ordinary form.

Incidentally it may be mentioned that the use of small tubes and the recent application of graphite as a cylinder lubricant would permit the employment of much higher pressures than have hitherto been possible. Mr. Maxim's tubes stand 500 pounds pressure per square inch with a large factor of safety.

A boiler resembling the one described above has recently been employed by Mr. Thornycroft on H. M. S. Speedy, as mentioned above. The results obtained were very satisfactory; 200 pounds of steam were generated in a 600-h. p. boiler in 25 minutes. A great saving in weight is reported (about 20 tons less than other boilers of the same capacity), due largely to the smaller amount of water carried in the boiler. Forced circulation does not seem to have been used, the fuel—coal—burning comparatively slowly, even with forced draught, so that this was not necessary, nor possible, on account of the great grate area necessary.

A New Monthly Magazine.

We have received the first number of "Elektron," a new monthly magazine devoted to electricity and its allied interests, and welcome the new addition to the electrical periodical press. The number contains a round dozen of articles on various electrical subjects, besides editorial and miscellaneous notes and a list of patents issued during the month of January, the size of page being that of the typical monthly magazine. Mr. John E. Talbot is editor, the price of subscription is $3 per year and the place of publication is Boston.

Government Control of Electric Lighting.

In referring to this subject, Mr. Preece, in a recent address, remarked as follows: " It is all very well in the pioneer stage of any industry to let private enterprise have its full swing, but when an industry becomes a public necessity, and when the interests of the whole community are at stake, government, as the custodians of the public weal, must step in and assume the control. The accidents in the States are terrible in their number and fatality, and they strike the observant Englishman with dismay. The value of life there seems to be very much below par."

Comparative Value of Certain Wiring Plans and Some Wiring Pointers.

BY E. P ROBERTS.

THE statement is frequently made that the arrangement of wires, as shown in Fig. 8, gives the same potential at any point of the loop circuit, and that therefore it is the best arrangement, when considered from the standpoint of the lamp. That this is not a fact has, however, been shown, and that it is only true when the cross-section of the wire is made proportional to the current (as in Fig. 9) has also been demonstrated, although many "experts" are not acquainted with the fact. The writer has argued the case with a well-known and really first-class "expert," who, as an installer of apparatus, is one of the best in the country, and who claimed and still claims that Fig. 8 not only gives perfect distribution at any load, but takes the least possible copper for a given loss, and that its only disadvantage is that it is not convenient to test out same in case of trouble: also that the "theory" which can obtain the results tabulated below is "off," or the writer is. As the "theory" is Ohm's law, the writer suggested that the only error possible is in the application. The expert stated that he had erected a system, of the character shown by Fig. 8, and used two-thirds the copper required by Fig. 6, and a voltmeter showed that his statement was correct, and he did not care for any figures; he went by facts. This controversy furnished much food for thought, and could easily be made the text for an article; it is now only given, trusting that it will excite the reader to sufficient interest in the table to work out the results, and then, if he is a believer in the correctness of Ohm's law, he can judge for himself.

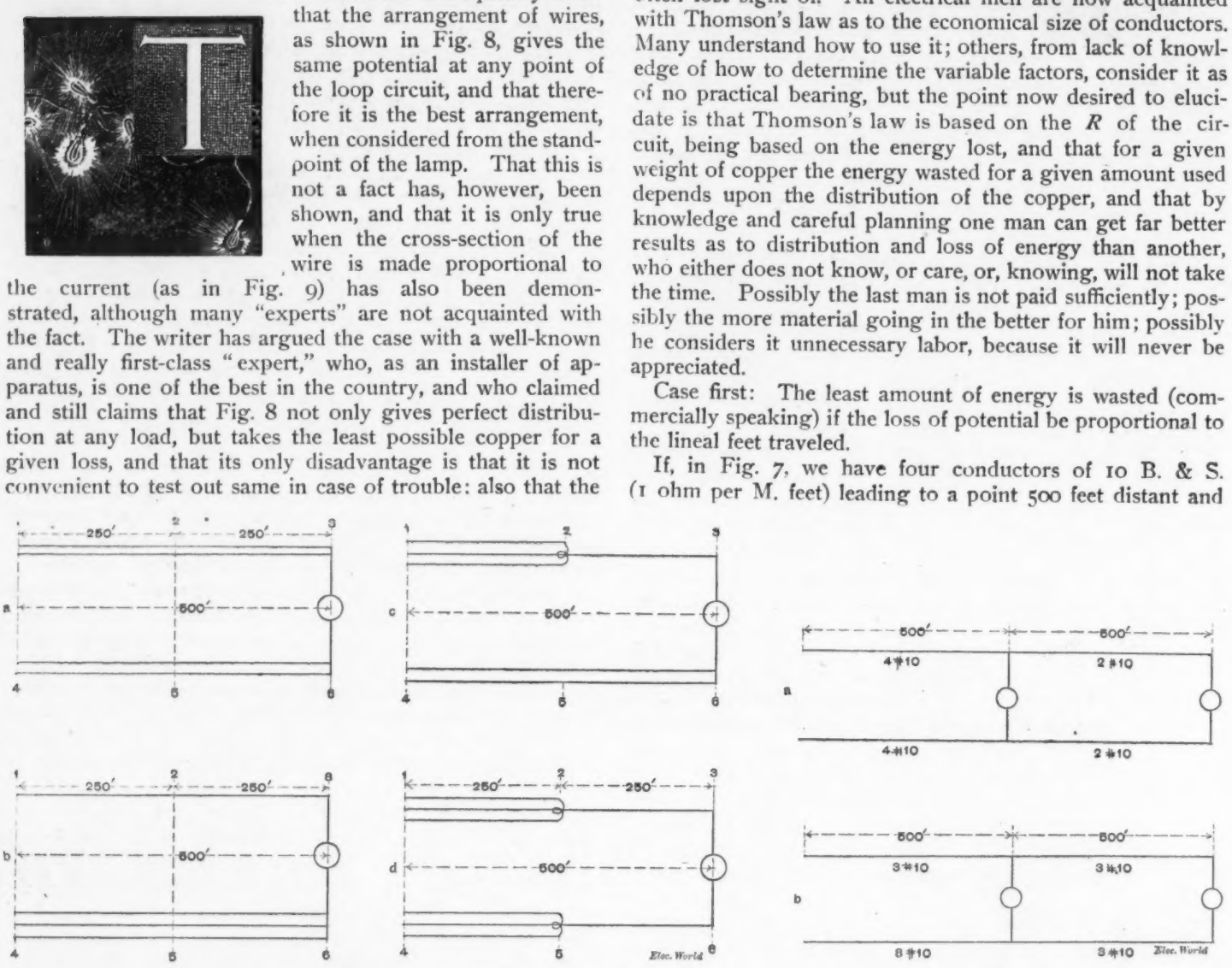


FIG. 1.

FIG. 2.

The method used for the calculation is the "drop of potential." In each case the same size wire is considered and, the R and C flow being known, the drop calculated. The C for each lamp is taken as constant, which, though not exactly correct, is sufficiently so. If the reader prefer, he can consider the translating devices, not as lamps, but of wire of constant R. The error, when lamps are considered, is toward compensation, as increased potential at any point increases C and lamp R decreases, but increased C cuts down potential. This must not be confused with distribution; the action is merely partly compensating for varying R with C, but the increased C exists and the lamp is being strained—the latter is not being compensated.

It may be well to premise the working out of the examples by some general statements which contain truths often lost sight of. All electrical men are now acquainted with Thomson's law as to the economical size of conductors. Many understand how to use it; others, from lack of knowledge of how to determine the variable factors, consider it as of no practical bearing, but the point now desired to elucidate is that Thomson's law is based on the R of the circuit, being based on the energy lost, and that for a given weight of copper the energy wasted for a given amount used depends upon the distribution of the copper, and that by knowledge and careful planning one man can get far better results as to distribution and loss of energy than another, who either does not know, or care, or, knowing, will not take the time. Possibly the last man is not paid sufficiently; possibly the more material going in the better for him; possibly he considers it unnecessary labor, because it will never be appreciated.

Case first: The least amount of energy is wasted (commercially speaking) if the loss of potential be proportional to the lineal feet traveled.

If, in Fig. 7, we have four conductors of 10 B. & S. (1 ohm per M. feet) leading to a point 500 feet distant and 10 amperes flow, and we connect up, as shown in a, b, c and d, we find that the drop and losses are as follows:

	A.		*B.*		*C.*		*D.*	
	P. D.	Watts.	P. D.	Watts.	P. D.	Watts.	P. D.	Watts.
1–2	1.25	.....	2.5	.....	.83	.....	.83	.....
2–3	1.25	.....	2.5	.....	2.50	.....	2.50	.....
4–5	1.25	.....	.88	.....	1.25	.....	2.50	.....
5–6	1.25	.....	.88	.....	1.25	.....	.83	.....
1–3	2.50	.....	5.	.....	3.33	.....	3.38	.....
4–6	2.50	.....	1.66	.....	2.5	.....	3.38	.....
Total,	15.	50.	6.66	66.	5.83	58.3	6.66	66.6

Evidently a certain total number of pounds of copper can be used to better advantage in a than in b, c or d, and it is not an equivalent to run one size of wire a certain distance and piece out with another size, even if the total pounds be the same.

For the sake of simplifying calculations, No. 10 wire, and multiples thereof, is used in all the examples. Another way would be to consider the R per millimetre foot, and it is a simpler method for those who are used to using the same.

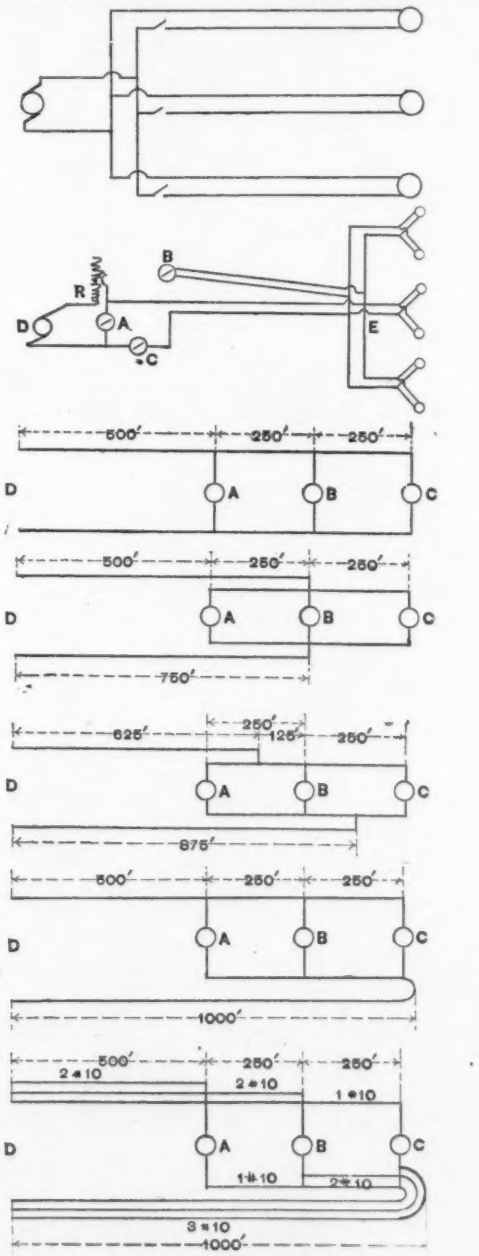
Another case: Fig. 2, a and b:

	Loss in 1–2 and 4–5.				Loss in 2–3 and 5–6.				Total.	
	Ohms.	*C.*	P. D.	Watts.	Ohms.	*C.*	P. D.	Watts.	P. D.	Watts.
A.....	.25	10	2.5	25	.508	5	2.50	12.50	5	37.50
B.....	.33⅓	10	3.3⅓	33⅓	.33⅓	5	1.66⅔	8.30	5	41.66

Note that although the drop from one end to the other is the same, there is nevertheless more energy wasted in b than in a, but also note that if incandescent lamps be the translating device used, b, would be better than a, be-

cause of better regulation. This does not affect the principles as to the least amount of energy lost, but shows that there may be more than one principle to consider.

It is generally known that the only way to obtain perfect regulation is to maintain constant P. D. at the dynamo, and to run a separate circuit to each set of devices, all of which must be "on" or "off" (Fig. 3). As this is generally impracticable, an effort is made to maintain constant P. D. as near the lamps as possible (see Fig. 4), where *D* represents a dynamo, *R* a resistance, so that P. D. at *E* can be controlled; (it may be controlled in other ways); *B* a voltmeter to indicate P. D. at *E;* a voltmeter, *A*, and ammeter, *C*, may be used, and the P. D. at *E* kept constant by knowing *R* from *D* to *E* and using Ohm's law. It may, however, be impossible to bring *E* very near the lamps, or the plant may be an isolated one, in which latter case compound wound machines are often depended upon for keeping the P. D. at the dynamo proportional to the current, and an effort be



FIGS. 3, 4, 5, 6, 7, 8 AND 9.

made (though probably it is not, and often cannot be made) to have circuits so divided as to all change load in about the same ratio. Whether there be a constant potential point at the dynamo, at some point along the leading wires or at some lamp, will only vary the conditions and results obtained, but the general deductions obtained from considering the following cases remain true.

Figs. 5, 6, 7, 8 and 9 show different methods of wiring for translating devices *A B C*. Each device to take 10 amperes

First—If each is to have the same size wire throughout, consider No. 10, because of convenience, and use two wires for a conductor in Figs. 5, 6, 7 and 8, and in Fig. 9 taper off, as shown, making cross-sections proportional to *C*.

If potential be kept constant at 100 volts at *B* and full load, then

	5.	6.	7.	8.	9.
P. D. at *B*.....	100.0	100.0	100.000	100.00	100.0
P. D. at *A*.....	105.0	97.5	99.375	101.25	100.0
P. D. at *C*.....	97.5	97.5	99.375	101.25	100.0
P. D. at *D*.....	120.0	122.5	125.000	127.50	121.5
Total feet wire	4,000.0	5,000.0	5,000.000	5,000.00	6,000.0

If potential be kept constant 100 volts at *B*, and *B* be cut down to half load, *A* be fully loaded and *C* one-quarter loaded, then

	5.	6.	7.	8.	9.
P. D. at *B*.....	100.00	100.00	100.00	100.00	100.00
P. D. at *A*.....	101.87	97.50	98.59	100.31	98.44
P. D. at *C*.....	99.37	99.37	100.47	101.56	101.25
P. D. at *D*.....	110.62	113.12	114.53	115.94	111.56

If potential be kept as before at *B*, and *A* be at one-half load, *B* at one-quarter load and *C* at full load, then

	5.	6.	7.	8.	9.
P. D. at *B*.....	100.00	100.00	100.00	100.00	100.00
P. D. at *A*.....	103.12	98.75	99.84	100.94	100.31
P. D. at *C*.....	97.50	97.50	98.59	99.69	98.44
P. D. at *D*.....	111.87	112.12	114.37	115.62	111.25

Many other conditions might be assumed, such as maintaining the P. D. at *D* constant, and that necessary for full load, which (if *D* be the feeder end) is often done in central stations; or making P. D. at *D* proportional to *C*, which is the case when using an over-compound dynamo, and taking *D* as the dynamo; but enough has been stated to show that No. 7 is better than No. 8, not only in weight of copper and energy lost, but in regulation at full load, and for most variations under varying loads.

Economy of Incandescent Lamps.

BY W. STUART-SMITH.

Why does the economy of incandescent lamps fall so rapidly after they have been burning a few hours?

Every electrician has asked himself and others this question, and a vast amount of time has been spent and expense incurred trying to find out. The result is that every well-informed electrician will answer "that the filament undergoes a change in structure that seems to decrease its illuminating power." The resistance of the filament and current taken vary but little, while the light-giving powers fall through a wide range. A decrease in the illuminating power would seem to indicate a decreased temperature, which, with a nearly constant current, could only be caused by an increase in the specific heat produced by a structural change, and this explanation is the generally accepted one. It is the purpose of this article to show that such an assumption is entirely unnecessary, and that a very simple and familiar phenomenon is sufficient to account for the fall of efficiency.

Referring to Lieutenant Eyre's article on incandescent lamp economy (The Electrical World, Jan. 13, 1894), we see there three sets of curves given, and first it is seen that all three sets of curves rise rapidly for periods varying from 40 to 100 hours, depending upon the original candle power of the lamps. A maximum is soon reached, after which all the curves fall away.

The increase of the current at once indicates a decreased resistance, and this is probably caused by the filament becoming more dense under the action of the heat, just as a piece of porcelain will contract permanently if raised to a temperature higher than that at which it was fired. Although the filament may not be any hotter than it was at some points in its manufacture, yet the temperature is maintained much longer, and thus may have the effect of a higher temperature maintained for a short time.

The curves are shown as rising in a straight line from the origin to a maximum; it is probable that greater care in

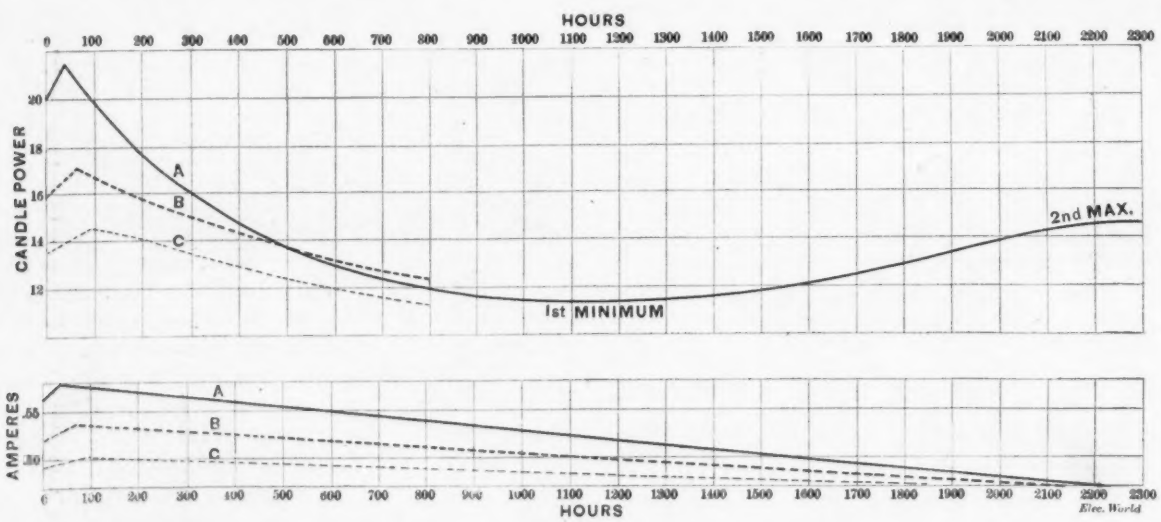
plotting would show a concave portion near the origin, followed by a point of contrary flexure, and a convex portion passing through a horizontal at a maximum, then another point of contrary flexure, followed by a curve of large radius.

The candle-power curve rises much more rapidly from the origin than the current, due, of course, to the fact that at the higher temperature produced by the extra current a larger percentage of the total energy consists of light-giving rays.

After passing through a maximum the current falls slowly and steadily, the curve being very nearly a straight line. This is, no doubt, caused by the resistance increasing as the filament becomes smaller, through vaporization. As the curve is so nearly a straight line, the current decreases exactly in proportion to the volume of the filament, and the temperature should remain constant, unless there is an increase in the specific heat.

A further examination of the candle power and efficiency curves will show that the slope becomes less and less with time, and if continued they would probably reach the horizontal, pass through a point of minimum value and then rise again to another maximum of less value than the first. This last point is not evident from the curves, but, I think, can be shown.

The current curves, if prolonged, will be found to intersect nearly in a point. If this is not accidental, it means that point when the filaments become so attenuated through vaporization that they become practically of no section. In practice they will break before reaching this point.



INCANDESCENT LAMP EFFICIENCY CURVES.

In my article on "Blackening of Incandescent Lamp Bulbs" (The Electrical World, Nov. 11, 1893) I suggested that the carbon filaments are not homogeneous, and that some portions volatilized more rapidly than others, and if this is true (as seems probable), a microscopic examination of filaments which have burned for some time will show them to have very irregular surfaces, being pitted and scored in every direction. During the early stages of illumination this would not have a deleterious effect, but, on the contrary, might add to the illuminating power by increasing the virtual surface, just as roughening the surface of a stove is beneficial by increasing the radiating surface. If this is true, then part of the increased illumination near the origin is due to this and part to the increased current, and the effects would be hard to separate. In any case, the effect of pitting would be small and would not prevent the point of maximum light-giving power coinciding with the point of maximum current. After a time, however, a totally different effect will occur. As the pittings and scorings increase in depth a point will be reached when the light emanating from the crests and hollows will be half a wave length apart, and when this occurs part of the light will be destroyed, with the result that the total illumination will begin to decrease. At first but few points will have the requisite depth for interference, and the diminution of light will be small, but as time goes on the number will greatly increase and interference will take place over the whole surface, and the effect will be greatly diminished illumination, due to the virtual decrease of illuminating surface. The effect will be the same as interference in the case of gratings, opals, Newton's rings, etc. Gratings, opals, etc., produce color effects, and it may be asked why, if this effect is the same, colors are not also produced. The answer is simple: Gratings, etc., are regular, and the results are even distribution of interference with consequent color effects, but in the case of the filaments, owing to non-homogeneity, the pittings and scorings will be very irregular, and the result will be that color effects from adjacent portions will be interspersed and the resulting effect will still be white light, though it will have less intensity than originally, on account of a portion of the light having been destroyed. If some color predominated, it would not show distinctly, but would be diffused throughout the mass of the illumination and give a general tint to the light, and it is well known that the color does change, becoming more red. Probably it also goes through other tints, but they are less noticeable, as the carbon deposit on the glass tends to absorb them and leave the red, which have the longest waves.

According to this view, the intensity of the illumination of every point of the filament remains the same as before, but the combined effect is less, owing to partial destruction just off the surface. Similar reasoning shows that the carbon is actually heated to the same temperature at all times during its life, but if the radiated heat should be measured it would be found to decrease, owing to interference as before. All this, of course, is independent of the effect of the carbon deposited on the glass. That is a mechanical interference and has nothing to do with the light-giving power of the filament. It is the filament which is being considered here and not the lamp as a whole.

It can now be seen why the slope of the curves decrease and approach a horizontal; in fact, why they must reach a minimum value, and then rise again to another maximum, to be followed by a second minimum, etc. As the pits and scores grow there comes a time when a maximum number have the right depth and size to produce a maximum interference, and at this point the virtual surface and consequent illumination will be a minimum, and the candle power and efficiency curves will both reach a horizontal. Beyond this point interference begins to decrease and the curves begin to rise, but at a less angle than that at which descent

was made, because as the filament wears away the current decreases. After a time the pits and scores will reach such a size that the virtual surface will be nearly that of the actual area of the carbon, and the candle power and illuminating curves will again pass through a maximum. This, however, will be less than before, because now the actual surface of the filament is less than originally, on account of the vaporization which has taken place. Theoretically, there should be a series of waves similar to sine curves, but having the part below the axis larger than the part above. They would be drawn about an oblique axis, to which they would tend to approach as the filament wore away. After the first wave they would tend to become complex, because the pits would then have considerable size and other pits would form within them and the effects would be superimposed. This recurrence of waves assumes, of course, that the carbons had so much section that they could stand the excessive scoring and pitting without breaking. In practice with lamps of high candle power and stout carbons, the second maximum might be reached, but probably nothing beyond that, and even this might not be noticed, on account of the blackening of the globes.

High candle-power lamps would feel the effect of this scoring and pitting sooner, because, owing to the greater size and consequent greater want of homogeneity, the pitting and scoring would be more rapid, and thus the more rapid falling off of illumination in high candle-power lamps is accounted for. It is even possible that with such lamps several maxima and minima might occur during the life, though, owing to the pitting within pits, as above explained, and the consequent superimposed curves, a steady illumination might take place, or, rather, the oblique axis might be reached by the candle-power curve. It could not become permanently horizontal, because the filament wears away and the current falls constantly. However, when the oblique axis was practically reached, the efficiency curve would become a horizontal line or a curve waving slightly above and below a horizontal. When this occurs, the efficiency should be nearly the original value because, though the illumination would be less, it would be practically proportional to the current.

The explanation given accounts for all the eccentricities of filaments, and points out the line to be followed in order to produce lamps that shall maintain high efficiency throughout their life.

The original cause is want of homogeneity, and probably this can never be overcome so long as organic, structural material is used for making filaments. It shows that a non-structural amorphous mass should be used as original material, and this must be chemically produced in such a manner as to be absolutely homogeneous. This being the case, the filaments will wear away evenly without pitting, and though the candle power will fall steadily as the filament wears away, it will still remain proportional to the current, and the efficiency will retain a constant value equal to the maximum near the origin.

Owing to the fact that experiments are made on lamps as a whole, the fall of efficiency and candle power observed are the combined effects of the lessened efficiency of the filament and increased absorption by the deposit on the globe. This absorption not only causes the curves to fall to a lower value and gives the oblique axis a greater inclination than it would otherwise have, but it also causes the minimum values of these curves to be reached at a later period, or the minima of the lamp are both lower and later than the minima of the filament.

Also, even if the filament had so much stock that after a time equilibrium in interference might be attained and the efficiency curve of the filament become a horizontal line, the continually increasing deposit would cause the curve for the lamp to slope downward.

Electricity in the Capitol City.

WASHINGTON was happily chosen as the convention city, for not only is it favorably located for the majority of the members of the National Electric Light Association, but it possesses attractions which no other city in the country can claim. While its chief features may already be familiar, a very brief glance at some of the principal points of interest from an electrical standpoint may prove of value.

PLAN OF THE CITY.

The Capitol is located at the geographical centre of the city. Commencing at the Capitol and running north, east and south are respectively North Capitol, East Capitol and South Capitol streets, which, with the government reservation known as the mall, running from the Capitol to the Executive Mansion on the west, divides the city into four sections or quarters. These are known as Northeast (N. E.), Southeast (S. E.), Northwest (N. W.) and Southwest (S. W.) The streets running east and west are designated by the letters of the alphabet, while those running north and south are numbered. Each block is assigned 100 numbers. Hence, to find any address requires but a moment's thought, as, for instance, wishing to locate 659 Eighth street, N. W., we know that it is between F and G streets (F being the sixth letter) on Eighth street in the northwest section of the city.

CONVENTION HEADQUARTERS.

The Ebbitt House, located at the southeast corner of 14th and F streets, N. W., has been chosen as convention headquarters. It is but natural that this selection was made, as it has been for years the headquarters for every prominent gathering at the National Capital. No better selection could possibly have been made, as it is very central, being but one square from the Treasury and Executive Mansion; two squares from the State, War, and Navy buildings and Corcoran Gallery of Art, and only one block from Grand Army Hall, where the convention will be held. The latter place is on Pennsylvania avenue, between 14th and 15th streets, N. W. Beautiful souvenirs of the city will be given to the visitors by the liberal management of this most excellent hotel. In these will be found half-tone engravings of the principal sights, together with a brief sketch of the interesting features of each. The red parlor on the first floor of the Ebbitt House will be thrown open for exhibitors. It is quite roomy, well lighted and should prove a very convenient location.

ELECTRICAL FEATURES.

A short description of the United States Electric Lighting Company's plant, located at the corner of 13 1-2 and B streets N. W., although by no means a model of modern plants, will perhaps be of interest.

The boiler plant of 3,450 h. p. is composed of eight 100-h. p. tubular boilers, two 200-h. p. Campbell & Zell water-tube boilers, and six 375-h. p. National water-tube boilers. As will be seen by the floor plan, Fig. 2, the engine room is arranged in the form of half of a hollow square, the boilers being placed in the central area. Steam is distributed through 14-inch mains having branches of the required sizes.

The power plant is made up as follows: Two 500-h. p. tandem compound Green engines belted direct to four 175-kw. Edison generators, one 250-h. p. tandem compound Green engine direct belted to four 50-arc Thomson-Houston generators. These engines are supplied with jet condensers, but owing to a lack of water supply the engines are run non-condensing; two 200-h. p. simple Green engines are direct belted to two 2,000-light Thomson-Houston alternators;

these dynamos run at 1,170 volts with full load. Next to these are two 100-h. p. New York Safety engines, driving four 50-light Thomson-Houston arc machines. Beyond these in the order in which they are named are one 100-h. p. New York Safety engine, running a 1,300-light Thomson-Houston alternator; one 100-h. p. Ide engine, running two 50-arc Thomson-Houston generators; one 100-h. p. New York Safety engine, running two 50-arc Thomson-Houston generators; one 100-h. p. Ide engine, running two 50-arc Thomson-Houston generators; one 100-h. p. New York Safety engine, running four 30-arc Thomson-Houston generators. In the south wing are located six 150-h. p. Armington & Sims engines, belted direct to 60 kw. Edison generators, each running two dynamos. There are also one 80 and one 30 h. p. Westinghouse engines, running 50 and 20 arc Thomson-Houston generators respectively.

Heavy copper bus bars are arranged along the outer wall of the building, and to these the generators are connected by means of bare copper rods. The controlling apparatus is arranged in a gallery, built for the purpose, where are also to be found the office of the superintendent and electrical repair shop. In the central portion of the west side is located lathe, drill press and engine room is arranged a 5-ton travelling crane for handling heavy work. Underground conduits are used in distributing current throughout the city. The present officers of the company are Clark, general manager; Mr. F. H. Chamberlain, superintendent; Mr. W. H. Fisk, chief engineer. With the exception of President Thomas the management is new, and although only two months have passed since their appointment, many improvements have already been made, and it is safe to predict that the condition of the plant will be greatly improved by the end of the present year.

ELECTRICAL FEATURES AT THE U. S. PATENT OFFICE.

The Patent Office is located between 7th and 9th and F and G streets, N. W., occupying nearly two full

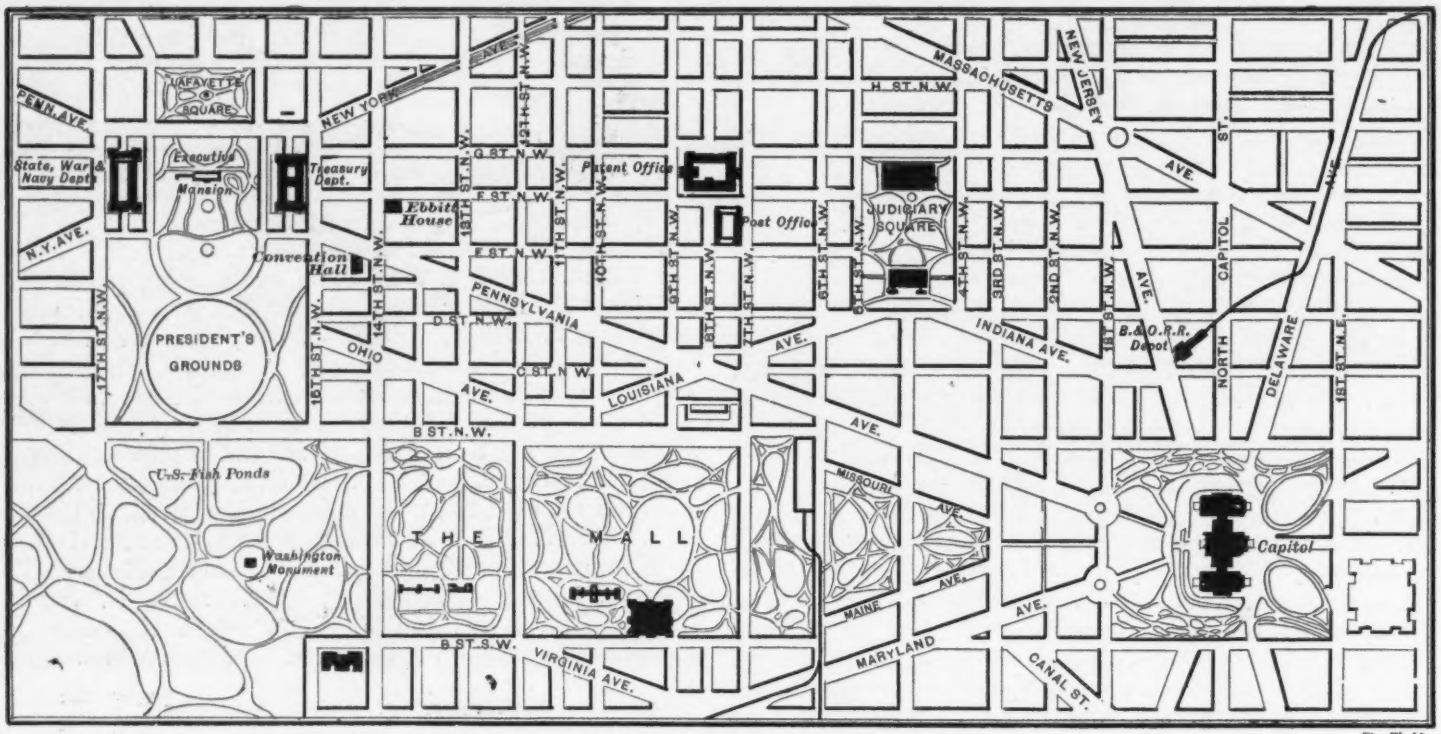


FIG. 1.—MAP OF CENTRAL WASHINGTON.

squares. Here are stored many interesting models, a few of which bear upon the early inventions for the production of electricity. It is quite interesting to compare the crude apparatus, as first brought out, with the perfected machines of to-day.

In a case located on the second floor and in the centre of the south corridor wil be found models of early inven-

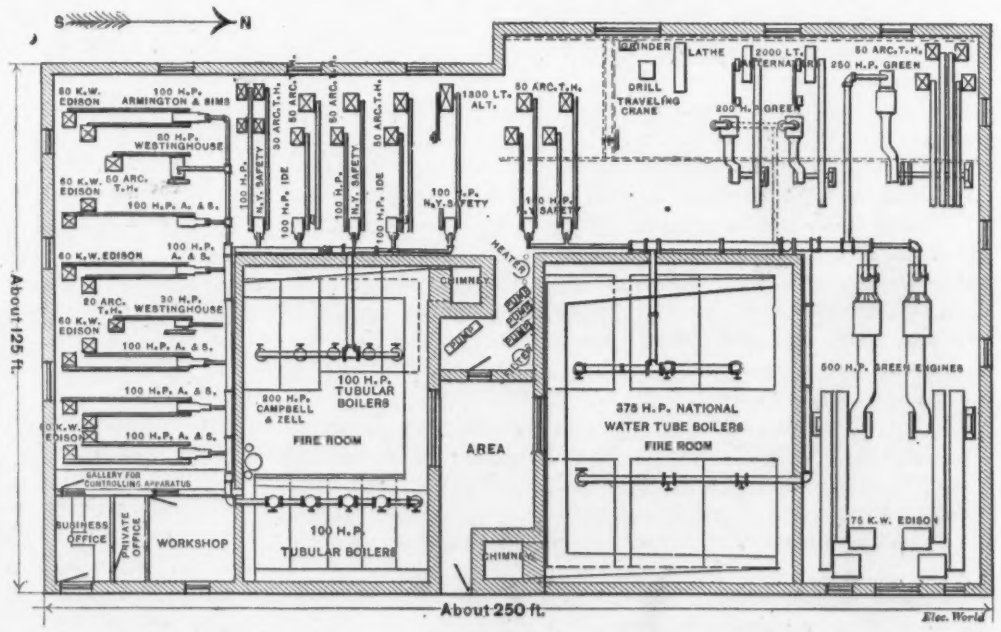


FIG. 2.—PLAN OF U. S. ELECTRIC LIGHTING CO.'S STATION.

tions as follows: Faraday's electromagnet, a reproduction of the first electromagnet ever made, constructed from the description in Faraday's "Experimental Researches"; Pixii's dynamo, a working model of the earliest form of this dynamo constructed from the description in "Electricity in the Service of Man"; Henry's reciprocating motor, a work-

ing model constructed from the description and drawing in vol. XX. of "Sellman's Magazine"; Jacobi's motor, a working model of this motor of 1834 constructed from the earliest record of the same found in a translation of a description by Jacobi in "Sellman's Magazine"; Davenport's motor of 1837, the original Patent Office model filed with the application on which patent No. 132 was granted to him Feb. 25, 1837; the model shows the permanent magnets; a model of Stimpson's electromagnetic engine is also shown. Besides these there are many other models exhibited showing the patented ideas of Lillie, Neff, Page, Carpenter, Shepherd, Bergnes, Berloiz, Wilde, Lontin and D'Iremois, Farmer, Sims, Paine, Gramme, Bishop, Fuller, Weston, Brush, Hursey, Ludwig, Edison, Thomson and Houston, Hochhausen, Griscom, Maxim, Van Depoele, Wood, Diehle, Lugo, Pfund, Little, Meyrowitz and Buchop, Heyer and Eckmeyer. Models of electric lighting patents are displayed covering the inventions of Collier and Baker, Gardiner and Blasson, Berloiz, Day, Wallace, Weston, Brush, Thomson-Houston, Edison, Sawyer, Maxim, Kieth, Van Depoele and Ward. Models of recently invented welding machines by Prof. Thomson are also shown. The telegraph and telephone are amply represented by many models of early inventions.

ELECTRICITY AT THE NAVY YARD.

Electricity has only recently made slight advances in its practical application to naval warfare. Under the able supervision of Lieutenant S. Morgan applied electricity as relating to gunnery is steadily advancing. He has already devised a very novel method of firing by electricity, which is as follows: With the case in question a closed box was built upon the web of the left-hand bed plate. In this box a 3-cell battery of Exeter dry cells is placed. One pole of the battery is connected to the body of the gun, while the other is connected into one pole of a plug cut-out. The other pole of this cut-out is connected to a bridge made of an alloy of platinum and iridium located within the shell and around which is wound a layer of gun cotton. After passing through the shell the wire makes electrical connection with the interior of the gun. A plug having a flexible cord of some 20 feet in length attached to it is provided at the opposite end

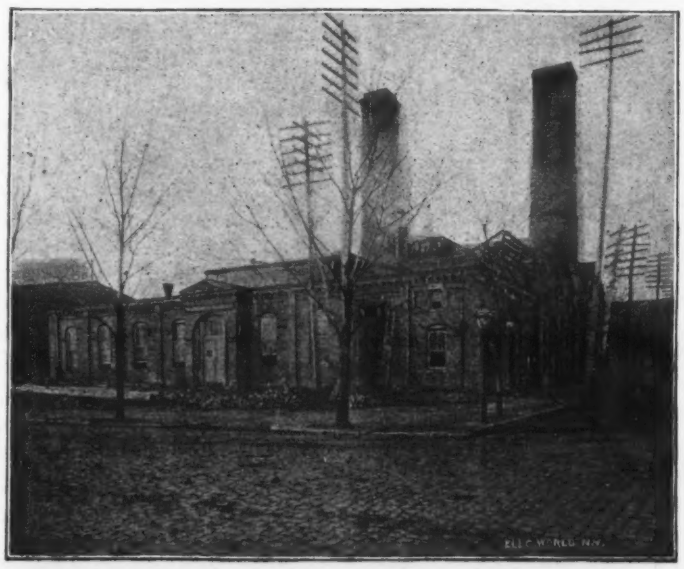


FIG. 3.—U. S. ELECTRIC LIGHTING CO.'S STATION.

with a handle which can be compressed by firmly grasping it. In compressing this handle the electrical circuit is completed and the charge exploded.

The electric motor, with screw power, is about to displace the ponderous hydraulic rams (and necessary piping) used in training and loading the guns.

The west gun shop is provided with portable electric drills, which have proven very advantageous for many kinds of work. They were manufactured by Thomas H. Dallett & Co., Philadelphia. There is little else of an electrical nature to interest one outside of the 10-ton electric crane built by William Sellers & Co., Philadelphia. However, the entire works are exceedingly interesting and should be visited by all who can possibly find time to do so.

ELECTRIC RAILWAYS.

By cable from the Navy Yard one can be taken direct to Georgetown, D. C., where will be found the Tennallytown

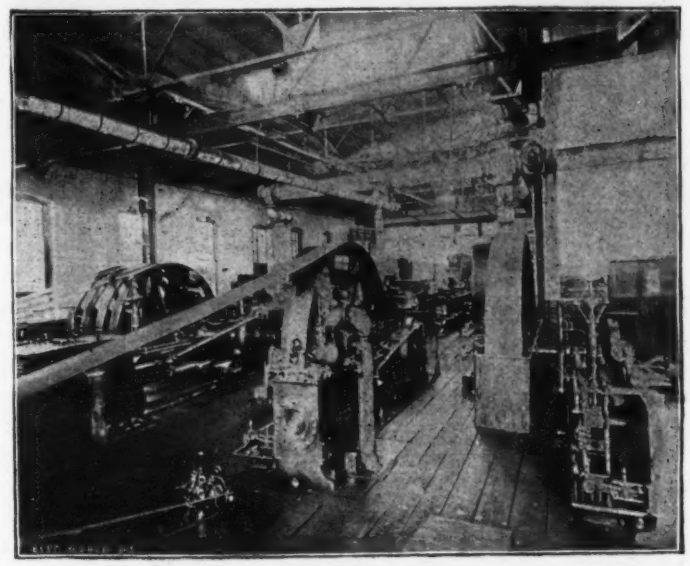


FIG. 4.—INTERIOR OF ELECTRIC LIGHTING COMPANY'S STATION.

and Washington Electric Railway. By crossing Aqueduct bridge a line of the Wheelless Underground Conduit Electric Railway may be found. Through financial difficulties the road has been shut down, but a move is now on foot which will probably again place it in operation. The U street line of the Rock Creek Railway, which is operated upon the Love system, should be visited. This line was fully described in The Electrical World of Jan. 14, 1893.

ELECTRICITY IN THE CENSUS OFFICE.

The honorable Commissioner of Labor, Mr. Carroll D. Wright, has forwarded to the secretary of the National Electric Light Association an invitation to visit the Census Office and witness the working of the Hollerith electric tabulating machines, so successfully used during the last census.

There is but little doubt that those who attend the convention will be amply repaid, for while the electrical features of Washington are few, there is so much else of historical value and interest that their time can be well occupied.

The Capitol, National Museum, Smithsonian Institution, Bureau of Engraving and Printing and Treasury are full of interesting sights and should be visited if possible.

Direct vs. Belt Driving.

Mr. Preece, in his recent paper on electricity in the United States, in referring to the subject of direct driving, states: "The reports of our performances in England are much sought after, and I think one influence of the Chicago gathering will be to convert American engineers to direct driving. The elastic character of direct driving engines, gradually increasing in number and capacity with the load, and the ability to shut down or turn on engine after engine as the load varies, are economical advantages of some value. The rapid regulation of small engines, the much smaller space occupied where space is so valuable, the smaller capital expenditure involved and the reduced working expenses, all give direct driving an advantage which should recommend itself to such eminently practical engineers as the Americans."

THE ELECTRICAL WORLD'S DIGEST OF CURRENT TECHNICAL ELECTRICAL LITERATURE

COMPILED FROM THE PRINCIPAL FOREIGN ELECTRICAL JOURNALS. BY CARL HERING.

ELECTRO-PHYSICS.

Dielectrine.—The Lond. "Elec.," Feb. 9, states that Mr. Hurmuzescu described this material before the French Physical Society; it is a mixture of paraffine and sulphur, is harder and less easily melted than the former and less easily cracked and less hygroscopic than the latter.

MAGNETISM.

Magnetic Shielding.—The Lond. "Elec. Rev.," Feb. 9, in an editorial briefly abstracts the paper of Prof. Ruecker on this subject in the "Phil. Mag." for January, in which he discusses shields separated by air gaps, as distinguished from continuous masses of iron.

The Electromagnet.—A French translation of the article mentioned in the Digest Feb. 17 is begun in "La Lum. Elec.," Feb. 3.

Electromagnetic Synchronizing.—"La Lum. Elec.," Feb. 3, reprints a mathematical paper by Mr. Cornu on this subject.

UNITS, MEASUREMENTS AND INSTRUMENTS.

Lord Kelvin's Amperemeter.—The Lond. "Elec. Rev.," Feb. 9, gives a short illustrated description, though not as complete as might be desired, of this instrument, called a current measurer; it is on the electro-dynamometer principle and is similar in construction to the one described in this paper some years ago; two small equal coils of fine wire are rigidly connected and suspended on modified knife edges, a pointer indicating their deflection; encircling these are two large fixed coils; the two coils of each pair are wound in opposite directions; the current is led to the movable coils through springs.

Instrument for Measuring Insulation.—In the "Elek. Zeit.," Feb. 1, Mr. Heim gives at considerable length an illustrated description of an instrument which he has devised for making insulation measurements at central stations. It is neither a coarse instrument for workmen nor a delicate laboratory one; it is for making reliable measurements up to a sufficient accuracy from 30 megohms to 1,000 ohms; it is a direct reading astatic galvanometer with a suspended needle.

Practical Unit of Self-Induction.—Mr. Whitwell, in the Lond. "Elec. Rev.," Feb. 9, endeavors to give briefly a clear notion of what the henry is; after a somewhat lengthy introduction he merely states that if the current increases by one absolute unit per second and also that the back E. M. F. of self-induction is one absolute unit of E. M. F., then the self-induction of the circuit will be one absolute unit of self-induction; he defines this absolute unit as follows: A circuit has one absolute unit of self-induction, if, when the current is uniformly increasing at the rate of one absolute unit per second, the back E. M. F is one absolute unit; if the current increases at the rate of one ampere per second and the back E. M. F. is one volt, then the self-induction is one henry; he shows that the dimension of self-induction is a length.

Kruppin, a New Resistance Material.—A translation of the article mentioned in the Digest Jan. 6 is given in abstract in the Lond. "Elec. Rev.," Feb. 9, in which also a number of the tables are given.

DYNAMOS AND MOTORS.

Unipolar Machines.—The "Elek. Zeit.," Feb. 1, contains another article by Mr. Marcher, in which he discusses the subject at some length, giving illustrations of several inoperative machines and discussing certain principles; in conclusion, he infers that the construction of a unipolar machine is not impossible and that he merely wishes to point out useless directions of research.

Irregularities in the Action of Dynamos.—The article from the French, mentioned in the Digest, is continued in the Lond. "Elec. Rev.," Feb. 9.

TRANSFORMERS.

Ironclad Transformer.—The "Elek. Zeit.," Feb. 9, quotes from an Italian paper, dated October, 1871, a statement made by Pacinotti, in which he refers to Ruhmkorff coils and states that he added an armature with the object of making a complete closed magnetic circuit, stating that by this means a larger deflection was obtained in a galvanometer, and suggesting that such an addition might be of advantage also in large Ruhmkorff apparatus.

ARC AND INCANDESCENT LIGHTS.

Arc Lamp for Projecting Lanterns.—The Lond. "Elec.," Feb. 9, gives a short illustrated description of the Davenport lamp, in which the lower rod is fed up by a spring against a metallic stop near the arc and the upper one is moved by a rack and pinion by hand; it will burn five minutes without attention; the carbons are set at an angle; from two to three times the amount of light is obtained as from the lime light, with less risk of injuring gelatine slides by the heat.

Incandescent Lamps.—The well-illustrated serial of Mr. Richard, taken apparently from patent specifications, is continued in "La Lum. Elec.," Feb. 3.

ELECTRIC RAILWAYS.

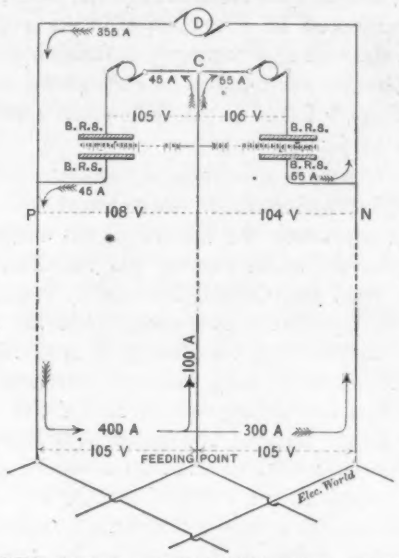
Railway Statistics for the United Kingdom.—The Lond. "Elec.," Feb. 9, publishes some tables of statistics and other information from the Board of Trade reports concerning street railways in general, no mention being made of electric railways in particular; the total number is 153, covering a length of almost 1,000 miles; the average total capital expended per mile is about $73,500, that for municipal lines being considerably less than that for lines in the hands of companies; the traffic is about 600,000,000 per annum; the net receipts for the past year are about 5 1-2 per cent. of the total expenditure, which does not allow for depreciation; detailed data are given for four roads.

Mr. Preece on Electric Railways in America.—In his recent address he states that the progress made is the most wonderful instance of growth of the electrical industry in the United States; he describes in detail some of the larger plants; regarding the trolley wire, he states that when alone it is not unsightly, but when protected with three guard wires and when the feeders are overhead, it becomes hideous, and he is surprised that the American community submits to it.

Application of Electricity in Public Works.—The illustrated article in "La. Lum. Elec.," describing the large traveling cranes used at Bilbao, is concluded in the issue of Feb. 3.

CENTRAL STATIONS, PLANTS, SYSTEMS AND APPLIANCES.

Three-Wire Compensating Device.—The following device is described in the Lond. "Elec. Rev.," Feb. 9, in an article on the Burnley station. The general arrangement is shown in the adjoining cut; the dynamo generates 230 volts and is



THREE-WIRE COMPENSATING DEVICE.

in connection with the central wire; the compensator consists of two armature coils wound on one drum, each for an output of 200 amperes and 110 volts (the output of the dynamo being 400 amperes); as shown, the compensator is connected to the outside wires through a battery of 120 accumulators of about 500 amperes each; the bars represent switches, by means of which a fewer or greater number of cells may be connected to either side; in this way it is possible to balance with only one engine and one dynamo.

Engines and Dynamos.—An editorial under this heading in the Lond. "Elec. Rev.," Feb. 9, discusses the subject of direct vs. indirect driving, claiming that there is no doubt that direct driving is best, having advantages in every respect, being cheaper in first cost, occupying less space, running cheaper, safer and at much less cost of maintenance; the only drawback being that it sometimes requires a large dynamo; it thinks there is a great future for the steam turbine; regarding single vs. double acting engines, it believes the former to be the better, and states that the single acting engine is running the largest amount of power in central stations in that country; it believes that about 75 per cent. of the electric lighting in that country and America is done by single acting engines; for direct coupling, gas engines have not been used with success.

Gas Engines in Central Stations.—Mr. Bourquin's article is concluded in "La Lum. Elec.," Feb. 3; he discusses at great length the advantages of using gas engines for generating electric light and particularly the combination of central stations and existing gas-producing plants, a system which he strongly advocates; he apparently gives nothing new. He also discusses the Van Rysselberghe hydraulic system, mentioned before in these columns, in which it is claimed to be more economical to transmit power hydraulically and transform it near the place of consumption into electricity; the chief argument is that the loss in hydraulic transmission is inversely proportional to the fifth power of the diameter, while in electric transmission it is inversely proportional to the square of the diameter; in the present paper it is argued that this system is no improvement; the same conclusion is arrived at regarding pneumatic transmission. In a former article he showed that a cubic metre of gas burned directly gives 91 candle-power hours, while with a gas engine and dynamo it can give 162 candle-power hours in incandescent lamps.

Double-Acting Gas Engines.—A communication to the Lond. "Elec.," Feb. 9, describes the Kilmarnock engine, which is claimed to be the only double-acting gas engine in England; a diagram is given for comparing the impulses at different loads for a number of different engines; it is started in a simple manner and at a moment's notice by a small boiler.

Mr. Preece on Electric Lighting in America.—In his recent address, mentioned elsewhere, Mr. Preece states that the accumulator in America has been a failure for electric lighting and that a very strong prejudice exists against its use. The feature which distinguishes American from English lighting is the persistent use of belting and countershafting, which in some stations is appalling to English eyes; he thinks that one influence of the Chicago gathering is to convert American engineers to direct driving. City work in such places as New York, Boston and Chicago, he says, is as solid and substantial as anything in England, but in country towns it is wretched; "if we are slower we do these things at least better in England." He states that when the industry becomes a public necessity and when the interests of the whole community are at stake, the government should assume control; the accidents in the United States, he claims, are terrible in their number, and strike the Englishman with dismay.

Average Output of Motors.—A note in the "Elek. Zeit.," Feb. 1, on the installation in a German town, gives a list of the motors and their power, from which it appears that out of 367 motors connected to that installation and representing a total of 87 h. p., 252 have 1-15 h. p., the next largest number being 32 of one h. p., while there are only four of more than 1 h. p.

Motive Power and Gearing.—Mr. Carter's serial is continued in the Lond. "Elec.," Feb. 9, in which he continues the discussion of the subject of fuel.

Self-Contained Condensing Plant.—The Lond. "Elec.," Feb. 9, gives a short illustrated description of the Allen engine, in which the condenser forms part of the machine, thus occupying much less space.

Burnley Station.—The Lond. "Elec. Rev.," Feb. 9, gives a brief illustrated description, showing the interior of the station and the switchboard; also a three-wire compensating device, for a description of which see the paragraph under that heading; the low tension three-wire system is used, the dynamos having the voltage of the outside mains, the load being balanced by means of the compensator.

Municipal Electrical Works.—The Lond. "Elec. Rev.," Feb. 9, abstracts briefly the same article which was mentioned in the Digest Jan. 27 on central stations in Germany.

Central Stations in Germany.—The "Elek. Zeit.," Feb. 1, publishes several communications concerning the article which was abstracted in the Digest Jan. 27.

Electric Lighting in London.—In a short article in the Lond. "Elec.," Feb. 9, curves are given showing the growth of various stations in London; the average rate of increase is about 10,000 lamps per year for each separate station.

Electric Lighting of London.—The Lond. "Elec. Eng.," Feb. 9, reprints the first part of a paper by Major General Webber, which is chiefly of local interest.

Kingston Station.—A well-illustrated description is published in the Lond. "Elec. Eng.," Feb. 9, the station being a small one, but said to be of very good design; it is a municipal undertaking; alternating currents are used.

Bordeaux.—"La Lum. Elec.," Feb. 3, gives a well-illustrated description of this railway, in which the Thomson-Houston apparatus is used.

Partnach.—The "Elek. Zeit.," Feb. 1, gives a brief illustrated description of this small alternating-current installa-

tion, driven by water power; it appears to involve nothing particularly interesting.

WIRES, WIRING AND CONDUITS.

Underground Mains in Glasgow.—The Lond. "Elec. Eng.," Feb. 9, reprints a paper by Mr. Lackie, in which he gives a good description of the electric mains in Glasgow. Bare copper strips one inch broad and 1-4 inch thick, of which two or more are laid together on top of each other, are run on insulators through troughs consisting of cast iron boxes laid in trenches 18 inches deep in the sidewalk; 15 men can lay 40 yards, completing the work entirely in one day; the troughs are jointed with red lead putty and are covered with iron covers cemented in the same way; a brick manhole, 4 feet square, is placed at the end of each length; like in this country, there are many cellars below the pavement, in which cases, as also in crossing streets, cast iron pipes are laid, through which insulated cables are pulled; the troughs are nearly, but not absolutely, water tight, and slope toward the manholes, where the water drains, or is drained off; the arc light circuits and the potential wires are carried alongside of the troughs in separate pipes; he states that the potential leads give more trouble than all the other mains put together; the mains have been in use for fully a year and a half, and have given no more trouble than insulated cables in pipes; he approves of the copper strips, but not of the iron culverts; he suggests covering the strips with a slight coating of some insulating material; he appears to prefer concrete or earthenware culverts; malleable iron pipes are led to the consumer's premises and the branch cables pulled through them. He is strongly in favor of corporations undertaking this work; in conclusion he discusses the recent explosions in these conduits.

Insulation Resistance.—In Mr. Guy's serial on "Electric Light and Power" in the Lond. "Elec. Eng.," Feb. 9, he discusses the subject of insulation resistance, giving three rules; in the first it is equal to the voltage divided by the current and multiplied by a constant, the value of which ranges from 500 to 100,000; the insulation is therefore a function of the total resistance of the conducting circuit and the reciprocal of the constant represents the leakage current, as a fractional part of the useful current; in the second rule it is equal to a constant divided by the number of 16 c. p. lamps, the constant for 100-volt circuits being from 100 to 10 megohms; for alternating currents it is customary to double the constant; in the third rule the constant is multiplied by the voltage and divided by the number of lamps.

Resistance of Stranded Cables.—Mr. Everett's article, mentioned in the Digest Feb. 17, is concluded in the Lond. "Elec. Eng.," Feb. 9; it is of a theoretical nature and the results do not appear to be of any very great practical value; a cable manufacturer informed him that the conductivity of a cable of a number of wires is not much less than that of the same number of straight wires whose length is equal to that of the cable.

Capacity of Cables.—In the Lond. "Elec. Rev.," Feb. 9, Mr. Appleyard discusses, with the aid of a number of illustrations, the statement that the capacity of a loop formed of two equal cables which are not earthed is half that of one of the cables using an earth return.

Networks of Conductors.—In an editorial on the miscalculation of mains in the Lond. "Elec.," Feb. 9, the nicety of the calculation of mains in Germany is contrasted with the methods used in England, in which shrewd judgment and experience rather than algebra are required in determining the section of a feeder; the editorial favors the former method.

Networks of Conductors.—The "Elek. Zeit.," Feb. 1, reprints at some length a mathematical discussion of the analytical treatment of the problem of the distribution of current in networks of conductors; examples are worked out.

TELEGRAPHY, TELEPHONY AND SIGNALS.

Bell with Pivoted Magnets.—Mr. Kohlfuerst in the "Elek. Zeit.," Feb. 1, describes and illustrates at considerable length an electric bell such as is used in Germany for giving loud railway signals; it has two electromagnets, one of which is pivoted and connected to the clapper, thus replacing the usual armature, the two electromagnets attracting each other.

Telegraphic Communication Between England and India.—The Lond. "Elec.," Feb. 9, publishes an article by Mr. Walker on this subject.

ELECTRO-CHEMISTRY.

Electrolysis of Alkaline Salts.—Mr. Blount, in the Lond. "Elec.," Feb. 9, discusses the nature of the reactions upon which electrolysis depends, basing his remarks on recent papers by Nourrison and Oettel; the energy required for the electrolysis of an equivalent of sodium chloride in aqueous solution is 470 calories, corresponding to 2.02 volts; that of sodium sulphate requires 2.15 volts; Nourrison arrives at the conclusion that the voltage required for the decomposition of all the alkali salts of the same acid have the same value, and that as the heat of neutralization of all the oxy-acids is nearly identical, the critical voltage for the electrolysis of their salts is also nearly a constant quantity; after discussing the results obtained in practice he concludes that more than half of the electrical output of a plant for the manufacture of alkali and bleach is wasted by causes that cannot be considered altogether inevitable.

Purification of Sewage.—The reprint in the Lond. "Elec. Eng.," Feb. 9, in referring to the experiment at Havre, in which the refuse drains into the street gutters, states that when the electrolyzed seawater was used there was not only an absence of bad odor, but that the gutters, which formerly were always black and soiled, were beautifully bleached, even the curb and flagstones becoming nearly white. A report of a municipal committee is quoted from, giving some figures, as also a reply from Mr. Hermite, in which he states that the supply was not sufficient, as there should be 20 litres per inhabitant at 0.25 gramme of chlorine per litre; he guarantees one kilogramme of chlorine per hour for 12 h. p., equivalent to 48 cubic metres of disinfectant per day at double the above strength.

Chatiliez Accumulator.—"La Lum. Elec.," Feb. 3, gives a description of this accumulator as used in the station at Montmedy; the description is not sufficiently clear to be understood without an illustration, but the accumulator seems to differ from the general type.

MISCELLANEOUS.

Lightning Rods.—In an article by Mr. Hoho in "La Lum. Elec.," Feb. 3, he separates lightning rods into two classes: first those of Franklin and second those of Melsens, stating that the latter are unfortunately not well known. Regarding the first, he claims that it is absolutely wrong to suppose that it protects a definite zone, which, he claims, is very variable, and cannot be determined; after discussing Franklin's lightning rod, he describes that of Melsens, the principle of which is to envelop the building with a metallic network, particularly the prominent points, connecting it with the building, especially with the metallic parts, and making numerous connections with the earth; it is improved by attaching numerous needle points to it, the advantages of which have been proven by experiments. The difference between the two systems, he states, is that the first provokes lightning, while the second protects the building; the second system is not based on any hypotheses, but on perfectly well-established principles; it does not increase the probabilities of a bolt of lightning; it has no influence on neighboring buildings; it is much cheaper, a better connection with the ground is obtained and the attention it requires is next to

nothing; buildings thus protected have never been known to have been struck; the system has been adopted in the principal public buildings in Belgium, was recommended by the French Academy of Sciences, especially for powder magazines, and was also adopted by the English Navy. He states that the statistics show that the accidents caused by lightning have lately increased in a nearly geometric progression, and that the probable causes of this are the disappearance of the forests and the increased use of metals in the construction of buildings.

Cooking.—Mr. Binswanger, in the Lond. "Elec.," Feb. 9, states that the method proposed by Mr. Fessenden in The Electrical World, in which the heat losses are reduced by reflecting surfaces, is not new, as he has used it for some time; he finds practical difficulties exist, which reduce the advantages, but adds that bright and smooth surfaces should be used as much as possible in electrically-heated ovens, as the loss from the usual surfaces is so great as to make the oven practically useless; he gives the results of an experiment, and finds that 950 watts for ten minutes raised the temperature from 60° to 330° Fahrenheit when the outside was bright polished brass and the inside enameled, while 970 watts for ten minutes raised the temperature from 59° to 165° Fahrenheit when the outside was blackened and the inside ordinary sheet iron.

Electricity in the United States.—Mr. Preece's paper, mentioned in the Digest Feb. 17, is continued in the Lond. "Elec. Eng.," Feb. 2; the first part is also given in the Lond. "Elec.," Feb. 2. The telephone systems and details are described at some length, but few comparisons being made between the two countries, and few opinions being expressed; regarding trunk working, he states that it is wonderfully well done; regarding long-distance working, he states that he tested the circuits and found their working remarkably good, "it was difficult to say that it was better or worse than the working of our London-Paris line." A section is devoted to the congress, in which, however, no opinions are expressed, it being merely descriptive. In the section on the exhibition he speaks of it in glowing terms. In the section on electric lighting he states that it has not made the rapid progress during the past nine years which was expected from the very great rate of growth during the previous four years; incandescent lighting, he states, is more general in public places than it is in England, but in private houses it is not used as generally as in England; the cost of production of electric energy differs very little from that in England; it is diminishing and will certainly far exceed in economy the production of gas; the incandescent lamps are better than those in England.

Blowpipe.—The Lond. "Elec.," Feb. 9, calls attention to a description in the "Chemical News" by Mr. Warren, of a blowpipe made of a water voltameter arranged so that the electrolytic gases pass up through a couple of tubes to an oxyhydrogen blowpipe; if 50 of these in series are connected to central station mains, it is thought that the apparatus ought to maintain a long, steady flame of intense temperature.

The Electrical Industry in the United States.—A series of articles by Mr. Brunswick is begun in "La Lum. Elec.," Jan. 27, based on an official report to the French Minister of Commerce. In the first chapter the industrial conditions in France and America are discussed; the second chapter deals with the electric light.

Keely Reminiscences.—In a communication to the Lond "Elec. Rev.," Feb. 2, Prof. Elihu Thomson describes some observations made by himself at Keely's exhibitions.

Heinrich Hertz and His Work.—"La Lum. Elec.," Feb. 3, publishes an article by Mr. Brunhes, describing Hertz's researches.

Street Railway Storage Traction.

BY J. K. PUMPELLY.

Mr. Albert Stetson, in his paper read before the American Institute of Electrical Engineers on the practicability of electric conduit railways, makes some very surprising criticisms on the use of storage batteries for electric roads, which, although true to a certain extent, are in the main unjust. When he states that the experiments of "the Electric Power Storage Company in England and those of the Julien company in this country exhaust the possibilities, under commercial conditions, and that we have seen no better batteries than theirs," the criticism is far too broad. Mr. Stetson may be right in his opinion as to general commercial results, but the same might well be said of cable traction in many cities, where the commercial conditions are such that no dividends have been paid, but still not prove that large ones are not paid on some cable roads.

Under the improvements of these later days made on the old Plante process accumulators have been put to practical work in several instances and to such a successful purpose that the old Faure process of applied oxides, such as used in the systems cited by Mr. Stetson, must be relegated to a past age. It is pretty well known by men who have studied the subject undoubtedly quite as much as Mr. Stetson, that there are now on the market more efficient and more desirable storage batteries than any referred to by him in his paper. A battery, properly formed on the improved Plante process, in which the plates or electrodes are made of rolled lead integral in all its parts, with no joints or soldering, is so efficient and so evenly balanced in its electrochemical action that large discharges, even to 100 amperes from a 38-pound battery, can be sustained for some time in practical work; that is, 198 watts can be drawn from such cells for 25 minutes without any damaging effects, the batteries still performing their normal work, notwithstanding that the most economical output would be 10 per cent. of the rated capacity of the battery for 10 hours; that is, 20 ampere discharges instead of 100. Conservative battery makers to-day do not claim that storage battery traction is the ideal traction for all city railways, but that a good battery, such as above mentioned, would often fill the gap where a franchise for an electric road depends on the entire route through the city being electric traction, but forbids the use of the trolley along the crowded streets. Conserved and condensed energy in convenient or transportable form has certain advantages, such as compressed air or gas; at the same time the loss in conversion counts heavily against this method. Even coal, with all its possibilities of latent energy, is subject to tremendous loss in conversion to useful kinetic force. Thus, notwithstanding the horsepower energy of 1,200,000 foot pounds in one small storage battery may only equal the stored energy in 1 1-2 ounces of coal, it would be a very inconvenient matter to carry about a boiler and engine, however small, with water sufficient to generate the steam to produce this 1,200,000 foot pounds of energy. Stored energy in an accumulator, or rather converted energy, has advantages over other forms of portable energy, in that we can obtain from it light and kinetic force at the same time. As for the great weight of the battery, much depends in this respect on the work to be performed and the length of time allowed for doing it. This weight can be adapted to the length of the trip and the convenience of charging. However, this is hardly a point to be argued; it has all been tried in many ways, and found to have many objections, the principal one being weakness of the battery plates. As Mr. Stetson puts it in commercial parlance, "It don't pay," unless, as I have said before, there is no other way to carry out an electric road franchise. The writer does not care to wave the red flag before the eyes of the enraged

investors who have lost money by attempting the use of storage batteries on short roads, or of apologizing for what they have not done. Unfortunately, thus far, most money has been spent and lost in experimenting with the weakest form of batteries, in this country, at least. I could hardly say this had I not been constantly at work for six years in making storage batteries, in improving them and trying to overcome weak points in their mechanical and chemical construction. To return to the subject referred to above—the possibility of using the accumulator when the demand of the city authorities is for an electric road, the trolley wire being allowed to within a certain distance of the centre of city traffic, but denied in the more crowded streets—what were best to be done in such a case, since digging up of streets for sub-conduits is also assumed impossible? Cannot accumulators be made useful and commercial by so arranging the system that cars could leave the trolley wire at the outside of the city, and by the aid of storage batteries continue the trip through the city, around the loop and back to the trolley, when the connection with the battery car would put them in a position to be charged from the trolley wire? This, I think, could be done by using locomotive cars to carry the batteries and act as haulers of the passenger cars as trailers. To do this, 200 batteries placed on a short, compact car, half the length of the present grip car and carrying a 25 or 30 h. p. motor, could not only be charged from the 500-volt current through proper resistance on each car, but would drive the 500-volt motor after leaving the main wire with sufficiently reduced speed to suit the demands in the crowded streets. One motor could be on the locomotive car, or a motor could be on each passenger car, as now, receiving its current from the battery car. In systematizing such a plan as this, the batteries need be of no greater size and weight than would be necessary to make the loop trip, say 40 minutes. A motor to do this work, driven by 400 volts from 200 batteries, once again the voltage used on battery cars would not call for a greater output of current from the batteries than they would bear, if made in the way I have before mentioned. There would be one marked advantage on the generator line; that is, the batteries would be charged from the spare current while doing their regular work on the road, and hence the dynamo and engine would have a steady load at the maximum point when consumption of coal per horse power would be the most economical. The system should be so arranged that if the estimated travel demanded 40 cars to make the full number of trips, 20 would be on the trolley all the time and 20 on the loop free from the trolley. The plan in itself is not impracticable nor lacking in economy, providing a system adapted for it is thoroughly carried out. Much would depend on the accuracy of estimated work and load and time occupied. I think the plan has never been tried, although the system of storage battery locomotives is patented.

Storage Battery Traction.

The largest installation in the world for operating street cars by accumulators is in Paris, 25 cars being now in service, and this number is to be increased to 75 in the near future. The two roads using this system extend from the Ronde-Pont de Picardie, at St. Denis, the one to the Madeleine and the other to the Opera; a third line, about three miles long, from St. Ouen to Neuilly, is also soon to be operated in the same manner.

The battery used is the chloride accumulator, which in America is manufactured by the Electric Storage Battery Company, Drexel Building, Philadelphia, Pa. The first trials date from the month of February, 1892, and electric traction has been regularly employed on a portion of the two lines outside of the city walls of Paris since June 1. Horse cars have been entirely done away with on the Madeleine line since Oct. 1, and will soon be taken off the Opera line.

The car employed is illustrated with a trailer attached and has a capacity for 50 passengers. The speed, with full car, is seven and a half miles per hour, or of ten miles an hour outside of Paris, and a minimum rate of three and three-quarter miles on the heaviest grades, which are about 4 per cent. The company has the right of attaching another car, is seven and a half miler per hour, or ten miles an least sixty-five miles. Finally, the weight of the accumulators, including all accessories, does not exceed 6,000 pounds.

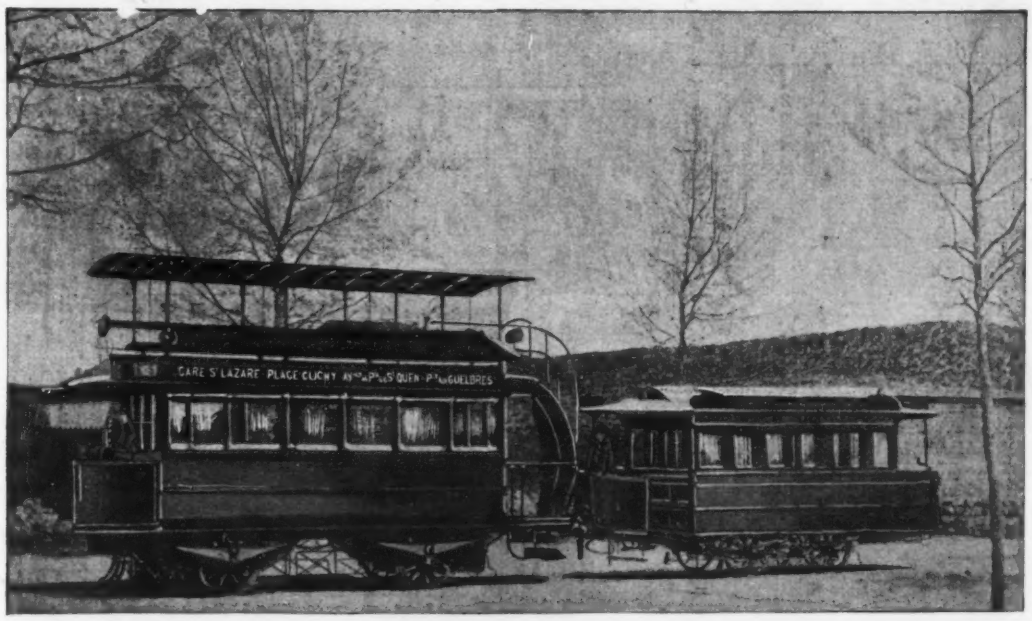
A motor is attached to each axle by double reduction gear wheels, the ratio between motor and axle being twelve to one. The gears are in an iron casing, the first pair completely immersed in oil. The electric motors are bipolar, of the Manchester type, with Gramme armature, series wound. The brushes are four carbon blocks. Each motor will develop, with a speed of 1,350, a power of 10,000 watts, with a difference of potential of 200 volts. Under these conditions the efficiency between motor and axle is 73 per cent.

The accumulators, as remarked before, are of the chloride type, manufactured by the Societe pour le Travail Electrique des Metaux, in France, and the Electric Storage Battery Company, in Philadelphia, and are placed under the seats of the car. There are one hundred and eight elements of eleven plates each contained in hard rubber boxes. The plates are seven and three-quarters inches by seven and three-quarters inches by a quarter-inch thick. The weight of an element is thirty-eight and a half pounds. These one hundred and eight batteries are divided into twelve groups of nine batteries each, contained in twelve wooden boxes, six on each side of the car, the batteries of each group being connected in series, and the two terminals attached to copper strips fastened to one of the partitions of the wooden box. The sets of accumulators are charged in parallel, with a constant electromotive force of 260 volts, and are left charging until they have absorbed a number of ampere hours, equal to that which they have rendered in service, plus an increase, on a basis of 85 per cent. efficiency. The number of ampere hours required to operate each line has been experimentally determined by means of a registering ammeter placed on a trial car. The duration of the charge is six hours for a battery which has furnished all its capacity of 230 ampere hours, or 52 h. p. hours. The yield in energy of the batteries is as high as 70 per cent., the batteries in service, with an electromotive force of upward of 200 volts, giving a discharge which on grades reaches 70 amperes, or nearly two amperes per pound of element. The average output on the level is about 35 amperes, which increases to 55 amperes on grades of 2 1-2 per cent. One charge of the batteries will run the car about forty miles on grooved rails and about seventy-five miles on ordinary T rails. In order to operate the car at the various speeds required in service the coupling of the cells of battery is changeable. In the car the batteries are divided into four parts or sub-batteries, each of 27 cells in series, which give, on closed circuit, about 50 volts. By means of a regulating switch, placed at the disposition of the driver, the three following couplings of batteries may be obtained: First, the four sub-batteries in parallel—E. M. F.—50 volts; second, two sub-batteries in series, two in parallel—E. M. F.—100 volts; third, four sub-batteries in series—E. M. F.—200 volts.

The speed of car is doubled in passing from one coupling to the other. The motors of the car are usually connected in series, but, by means of a switch, may be placed in parallel when greater speed or power is required, although this last combination is seldom used. This second switch also reverses the direction of running of the car by reversing the current in motor armatures, and by it also a motor may be cut out of service in case of damage by short circuiting it on the series combination. A single motor is sufficient to

run the car with a slightly reduced speed. The switch for altering the coupling of the sub-batteries consists of a barrel of non-conducting material, carrying three sets of copper strips, corresponding to the three couplings or combinations of the batteries. These strips become connected when the barrel is revolved on its axis between the metallic brushes, communicating with the sub-batteries. In passing from one position to another the current is broken before the strips are released from between the brushes, the break being made on special strips supplied with blocks of carbon, so arranged as to be easily replaced. The rapid deterioration of the metallic strips by sparking is thus avoided. The barrel is revolved by means of a lever. The switch or regulator which changes the couplings of the motors is composed of three commutators, operated by separate cranks, which are so interlocked that they cannot be operated except when the current is broken by the battery switch.

The daily service of the Madeleine route consists of 104 trips, or 52 round trips. Seven cars are operated on this line, some making eight and others nine trips, about 92 and 103 miles, while horse cars make not much more than 60 miles. Each car is operated with two sets of batteries, making from four to six consecutive trips, 46 to 69 miles, without recharge. The running time between terminals is fifty-five minutes, including stops. The weight of a full car is about 29,000 pounds, of which 5,700 pounds are for the batteries and their accessories and 7,700 pounds for the passengers. The mean tractile force is about 26 1-2 pounds per ton. The average results of operation on the Madeleine line for October, November and December, 1892, per car mile, are as follows, reduced to a basis of pounds of coal: Ampere hours, charged, 6.2 pounds; horse power hours, generated, 2.2 pounds; coal consumed, 9.2 pounds. The averages for a whole year would be lower, as the average for the three months considered is relatively high in consequence of the heavy condition of the road, due to mud, snow and ice. The service has been very regular and the receipts per car mile have increased to a marked degree. The favor of the public has been instantly won by the new, comfortable cars lighted by electricity. Encouraged by the good results obtained, the street car company has determined to introduce storage battery traction on all their lines. On the new cars which are to be built a system of regulation is to be employed whereby, in stopping the cars and in running down grades, the motors will become generators, and a portion of the energy previously given out by the accumulators restored.



STORAGE BATTERY CAR.

The Leonard System of Control for Electric Elevators

Elevators operated on the Leonard system have now been running for over two years without, it is claimed, any failure in the service, any expense for repairs, or the necessity of any attention beyond the oiling of the bearings. The Leonard system of control of electric motors differs essentially from other methods in that the regulation is effected entirely by varying the strength and direction of the current applied to the field of the generator, and not in the motor itself. In a well designed generator of moderate size the current of the field is perhaps one and one-half to two per cent. of its total output, so that the current varied is extremely small, and consequently the control is very small and sparkless. The system is applicable to any electric motor made without alterations. Another point of advantage claimed for this system is that the speed of the motor is practically independent of the load, or, in other words, that there is at command an infinite number of automatic speeds. A motor running slowly under only frictional loss can pick up its full load without slowing down appreciably, and when running slowly under full load its speed is not materially affected if the entire load is removed instantly. It is also claimed that the motor can be reversed when running under full load and the load quickly and smoothly retarded and then accelerated in the opposite direction without jar or sparking.

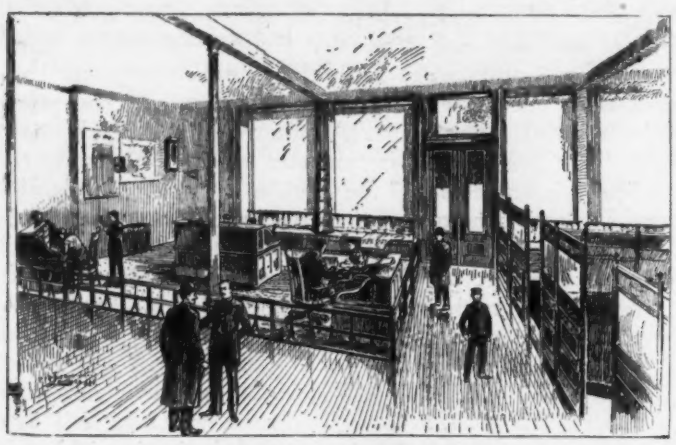
In the ordinary method of control by placing a rheostat in the path of the entire current more or less sparking at the contacts is inevitable, but in the Leonard system there are no contacts, except at the brushes and on the controller of the car. A flexible cable of No. 16 B. & S. gauge can be used between the motor and the controller, and in the case of an elevator constructed for handling 2,000 pounds the current carried by the cable for ordinary speeds is less than one ampere and sparking entirely avoided.

No mechanical brake is required for this system, as the retardation of the load is accomplished by causing the motor to become a generator, which feeds back current to the system. This not only saves the loss in friction of the ordinary mechanical brake, but is an actual gain. Another important point in the Leonard system is that the current drawn from the supply system in starting the elevator is the least used instead of being the maximum, as in the case of the ordinary system, and the current is gradually and automatically increased in proportion to the speed of the elevastor, so that the most perfect efficiency is realized even at the lowest speed.

The system is very simple, as there are no rheostats, dash pots, solenoids, indicators, mechanical brakes, automatic switches, pilot motors, or other similar devices. Among the companies licensed to use the Leonard system are Otis Brothers & Co., Crane Brothers, Hale & Co., Stokes & Parrish and the Whittier Machine Company, all well-known manufacturers of elevators.

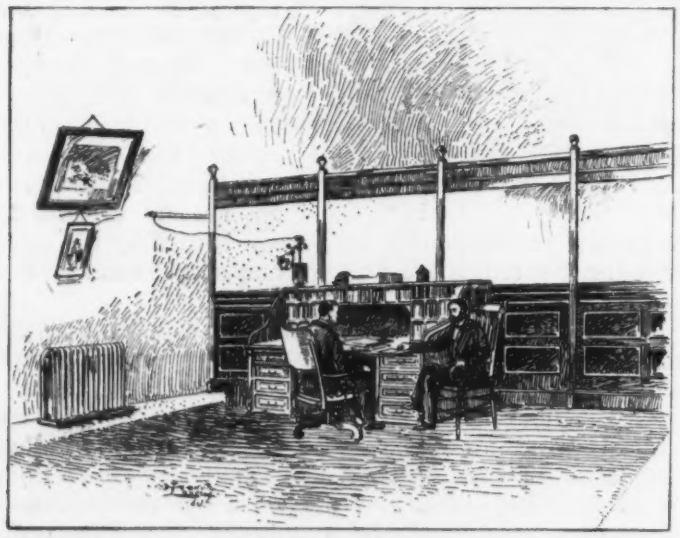
The Metropolitan Electric Company.

In its new quarters at 186-188 Fifth avenue, Chicago, Ill., the Metropolitan Electric Company now possesses every advantage for carrying on its large and growing business. In the face of the financial distress of the past year this company, under the able management of Mr. W. H. McKinlock, president, and Mr. Walter C. McKinlock, secretary, made such progress that it entirely outgrew its old quarters and was obliged to seek new quarters where it could have the advantages of combined offices, salesrooms, storeroom and



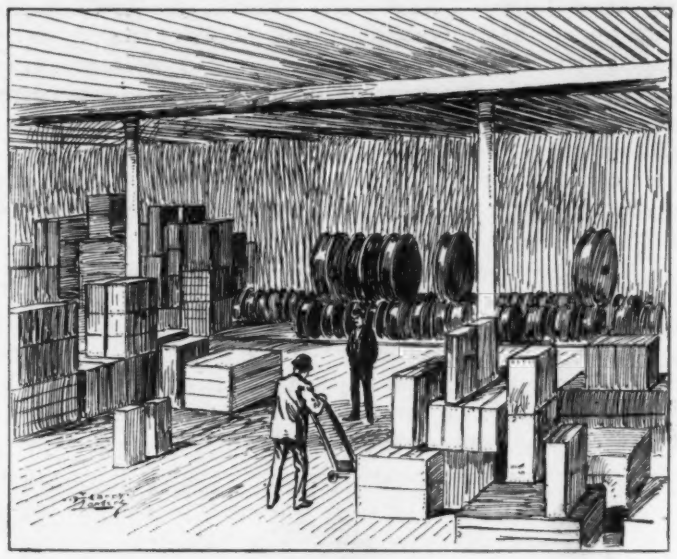
GENERAL OFFICES.

shipping department, and about the first of the year it settled in the large store at the above address. The accompanying illustrations will show how well fitted its new quarters are for the conduct of its business. On the ground floor, which consists of a room 50 feet by 150 feet, are the general offices, private offices of the president, the cashier's and stenographers' department, and shipping room and sales department. The front of the store is mostly of glass, which gives plenty of light on every part of the floor. As there is no partition between the salesroom and the shipping room,



PRESIDENT'S OFFICE.

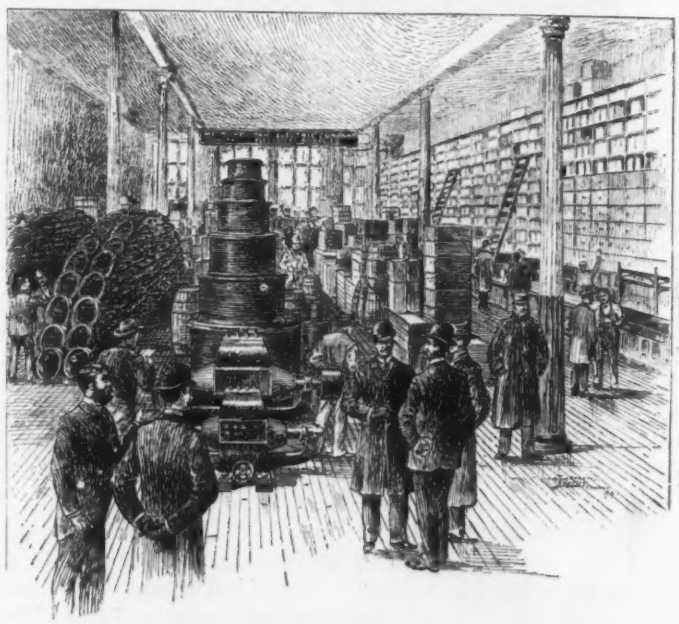
the salesman is always able to have personal supervision of the packing of goods. A basement under the salesroom, 50x110 feet in dimensions, is used as a storeroom, extending out under the sidewalk and affording ample room for the storage of inflammable material in accordance with the underwriters' rules. Here the N. I. R. insulated wires and cables, P. & B. compounds, incandescent lamps and various other supplies which this company handles may be seen in large quantities. The Metropolitan company is the general Western agent for the National India rubber wire, which is now made in all lines of insulated wires and cables, including telephone twin wire, lamp cord, electrolier wire, rubber tubing and concentric wire, as well as the more familiar forms. The Metropolitan incandescent lamp, which has been recently placed before the public, is claimed to possess unusual merits and is manufactured in all the standard candle powers. The well-known "Mac" tape is also handled by this company,



BASEMENT.

and the Paiste specialties, as well as the Standard Paint Company's P. & B. compounds, occupy a prominent place in this list. The Metropolitan transformer is a new piece of apparatus, which the company expects to place upon the market immediately, and which no doubt will meet with success.

The Metropolitan company has been fortunate in securing as manager Mr. J. J. Nate, whose long experience in the tele-



STORE ROOM.

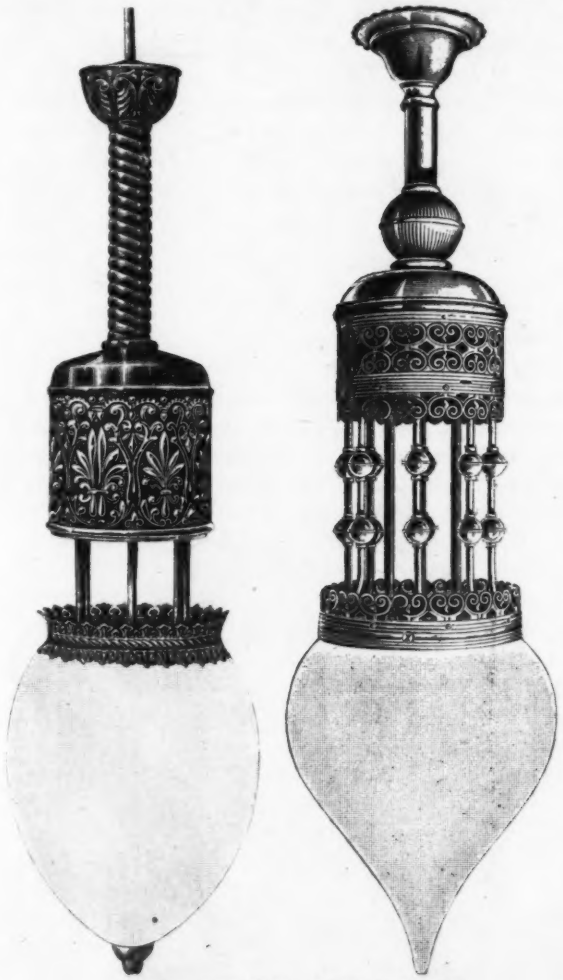
phone business and whose personal qualities render him particularly well qualified to fill this position.

A Loss to England.

We are informed that Mr. Gisbert Kapp, who has done such good work in England during the last twelve years, has accepted an appointment with the "Verband Deutscher Electrotechnicker" in Berlin.

Ornamental Arc Lamps.

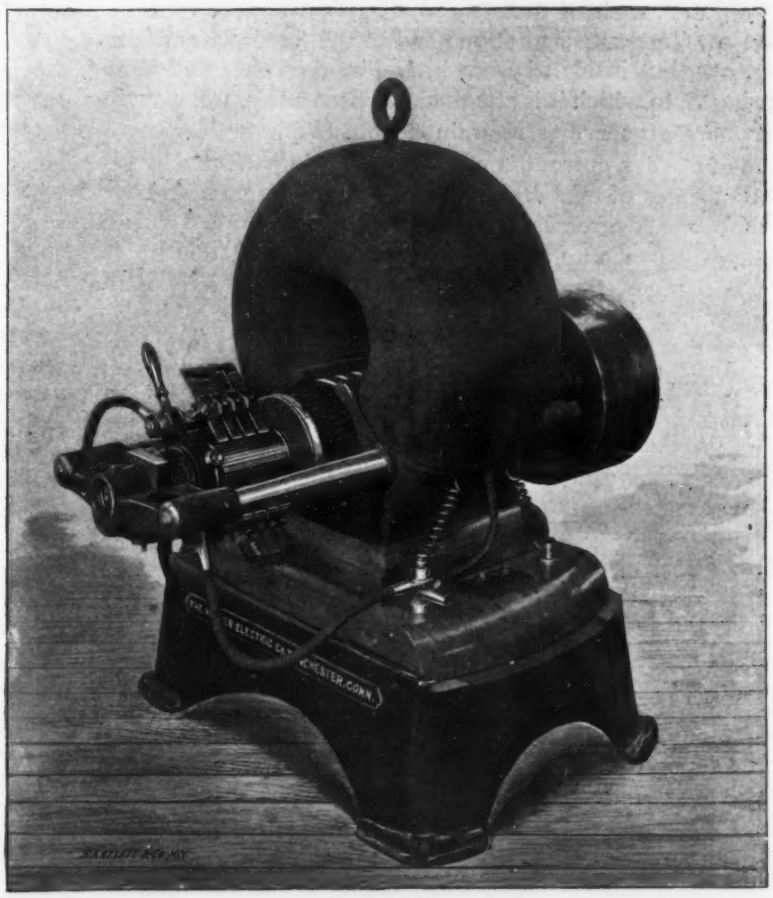
The arc lamps illustrated herewith, manufactured by the Clark Electric Company, 192 Broadway, New York, can be used with the high tension arc current or on low tension incandescent or alternating circuits. For alternating work especial claims are made. No extra appliances are required to be attached for this use, and the arcs do not make the "singing" or disagreeable noise generally associated with alternating arc lamps. This is a most important feature and weight is given to the claims by the great number of these lamps now employed for interior lighting with the most satisfactory results to the users. This, with the steady white light given by the Clark lamps and the entire absence of hissing, have given it an enviable reputation. In addition to the ornamental types illustrated the same company makes a lamp for exterior illumination that contains the same features as those illustrated, and is so constructed as to require no hood.



ORNAMENTAL ARC LAMPS.

New Mather Dynamo.

A new form of dynamo shown in the accompanying illustration has recently been placed upon the market by the Mather Electric Company, Manchester, Conn. The Mather type of machine has long been familiar to the electrical public, but this latest addition to the Mather generators possesses some new features which add to its efficiency and value. The field of this machine is made of cast steel, thus reducing its size and weight and increasing its permeability. Another important feature is the new self-oiling bearing, which is also provided with a device which shows at any moment just how much oil the bearing contains. The other details of this dynamo are similar to those of its predecessors. One of the claims of the Mather company is that the fields of their machines, being closely wound, are much less likely to burn out or be injured than those of the ordinary type. The workmanship, mechanical and electrical efficiency of these generators is of the highest. The machine shown in the illustration has a capacity of 31 kw., or between 450 and 500 incandescent lights.



NEW MATHER DYNAMO.

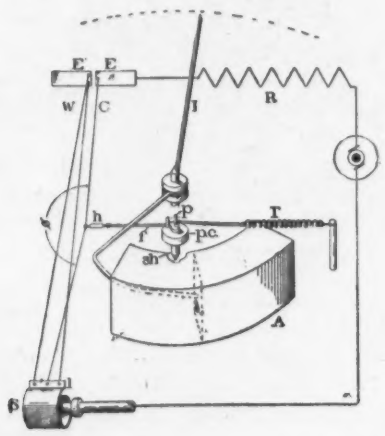
Voltmeters for Direct and Alternating Circuits.

The Cardew, Ayrton and other "hot water" voltmeters in which the expansion of the heated conductor records or indicates its amount by means of an index moving over a suitably graduated scale, have been largely used in commercial work, the former being for a number of years the only direct reading instrument capable of measuring alternating current and E. M. F. Such an instrument if standardized in any way for direct current measurements, will give exactly the same results when used on an alternating circuit, provided, of course, the circuit be wound non-inductively, since in either case the heating is proportional to the mean square of the current flow without other factors entering. Such an instrument, furthermore, can have no magnetic lag nor can it be influenced by neighboring magnetic fields or circuits, since the magnetic quality of its circuit has no part in the operation of the instrument.

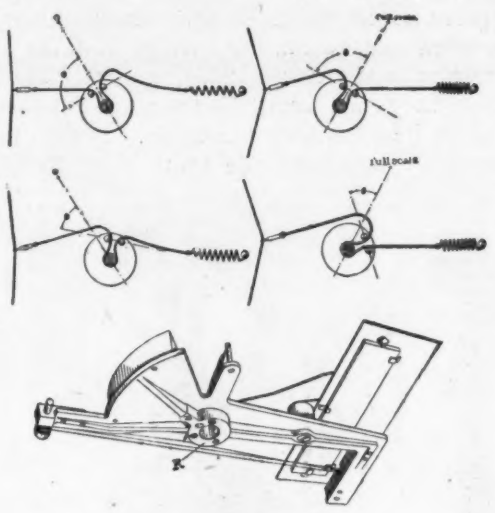
Messrs. Queen & Co., of Philadelphia, commenced two years ago, through their electrician, Mr. Willyoung, a thorough study of "hot-wire" instruments with the object of developing a complete series of voltmeters, which is now practically complete, and includes portable and laboratory instruments of all ranges from 1 to 3,000 volts, both single and double scale; switchboard voltmeters for isolated plants and central stations, with or without illuminated dials, and recording voltmeters of marked advance over existing types. All of these instruments are direct reading on either

direct or alternating circuits of any frequency, and are dead beat in action. The entire line of "hot-wire" instruments has been designated the "Acme" series, a name already associated with Queen & Co.'s specialties, such as testing sets and microscopes.

Fig. 1 illustrates, diagrammatically, the essential working parts of the instrument. The "hot" or working wire, *C*, extends from a fixed support, *E*, to a spirally wound phosphor bronze spring, *S*. Midway of its length it is connected to the extremity of a phosphor bronze filament or strip *f* which passes around the index shaft *s h*, engaging as it goes with two small pins *p*; the other extremity of the filament *f* is attached to a spiral "take-up" spring *T*, whose outer end is fixed. It is obvious that for a very small linear expansion of the working wire *C* there will be caused a many times magnified movement of the middle point in line of the filament *f*, which movement being taken up by *T* results in the carrying of the index *I* over the scale. The wires *W* are two or more in number, each of the same or nearly the same cross-section as *C* and attached at one end to the fixed plate *E'* similar to *E* but insulated from it, and at the other end to the spring *S*, to which it is attached. These wires, not carrying any current, serve to restrain *S* from taking up the expansion of *C* when current is passing, but being affected by general changes of temperature, such as room temperature, etc., o the same degree as *C*, let out *S* just enough for such changes to take up the linear expansion of *C*, due to the same changes, thus preventing any change of zero of the pointer for varying temperatures. It should also be observed that this compensation is effected instantly, no matter how varied the changes of temperature, since the wires *W* are of the same, or nearly the same, cross-section as *C*. n the "Acme" instruments absolutely no variation in reading can be detected whether the current be on for a second, a moment, or an hour, and the readings going to any point from zero are exactly the same as when dropping to the same current value from a higher one. The spiral spring *S* is used in preference to an elongated spring, on account of the fact that in an instrument in which the forces involved



The filament *f* is attached to the wire *C* by means of at minute glass connector, *h*, provided at each end with equally minute hooks of platinum wire. The purpose of this glass connector is to interpose between the wire *C* and the filamen *f* an effective insulation, thus avoiding any risk of accidental short circuits in other portions of the instrument. The platinum hook which engages with the wire *C* is fixed in position by a special cement studied out for the purpose and which but holds more firmly the more it is heated.



FIGS. 2, 3 AND 4.

An important function in this instrument is performed by of this arthe sthes thes htseh thes htseh hesth mard rodar d the filament *f* and the collar *p c*, with its pins. *p*, which

FIGS. 1 AND 5.—ACME "HOT WIRE" VOLTMETER.

are so small as in the "Acme" the effect of gravity upon a long spring would be considerable and would cause the readings to be less or greater, according as the spring were lower or higher than the other end of the wires, and small changes of level would, therefore, have to be guarded against. Upon the form of spring used gravity has no effect, and the readings are therefore not appreciably affected by very considerable differences of level; this freedom from level error is greatly assisted by the fact that the index is very exactly made and balanced so as to have its centre of gravity in its axis.

arrangement was devised to secure a fairly uniform scale throughout the whole range of the instrument, so that readings at a low point of the scale can be made with not greatly larger errors of reading than at high, and it performs its duty admirably. The manner of its operation may best be seen by inspection of Fig. 2, *a* and *b*, and Fig. 3, *a* and *b*, which represent enlarged diagrammatic views of the arrangement at zero and full scale deflection for two different positions of the collar *p c* with reference to the pinion *s h*. The collar, *p c*, carrying the two pins *p*, it must be understood, can be set upon the pinion *s h* so that the angle between the pins *p*,

and the pointer may be made anything desired. Referring now to Fig. 2, *a*, we see that the collar *p c* has been so set as to make $\Phi = 90°$. This causes the bend in the left-hand side of the filament to be very little at the zero point, and hence the effective radius of action of this part of the filament upon the shaft *s h* to be very short; a very small movement of the working wire is, therefore, considerably magnified by the index. At this position *b*, of the same figure, however, the bend in the filament has become great and the effective lever arm long. Consequently the scale divisions, which would be proportional to C^2 did the filament simply wrap about a cylindrical shaft, are greatly shortened, and the general tendency of the whole is to even up the scale throughout its entire range. Fig. 3, *a* and *b*, shows the character of the filament bends for $\Phi = 45°$; here the early divisions are closed more, the result being a scale somewhat crowded at each extremity and most open in the middle. By using other values Φ the scale may be made to vary in still differeut ways. In practice a value of $\Phi = 135°$ has given the best results, the scales so produced opening more and more from the beginning to the end of the scale, but not nearly so rapidly as if the C^2R law only were operative. The filament *f* is of tempered phosphor bronze, rolled flat from a wire 0.0015 inch in diameter. After rolling it is subjected to a careful course of treatment in order to age it and provide against changes of elasticity taking place with time.

To avoid any trouble from the instrument changing its reading or its zero when the containing case becomes strained mechanically in any way, either through handling or by the expansion and contraction coincident with general changes of temperature, the entire operative structure of the "Acme" instrument is supported upon a ribbed and very strong aluminium casting, which is itself attached to the containing case at but one point, shown clearly in Fig. 4.

As shown in Fig. 1, the "working" portion of the instrument is the wire *C*. This wire is about 0.0012 inch in diameter and 6 1-2 inches long; it is drawn from a special alloy of high specific resistance and great tensile strength, and is practically non-oxidizable. It requires to be heated to 150° C. to carry the index *I* over the whole scale, and this is effected with 7.5 volts and 1-15 ampere. This wire does not change its resistance for change of temperature, so that to make the instrument applicable to any range of E. M. F. desired, it is only necessary to employ a suitable amount of extra resistance of the same alloy in the shape of a multiplier. To avoid any error being produced by heat radiated from this extra resistance upon the working wire, the former is thoroughly partitioned off and arranged so that its heat radiation takes place to the external atmosphere.

Fig. 5 shows one of the perfected forms of this voltmeter, being the style intended for inspectors, engineers and others having accurate testing to do in various places. An extra resistance is supplied wound (for all ranges above 75 volts) in sections, in coil form and non-inductively, of double covered silk wire thoroughly soaked and baked in shellac. No two neighboring wires can have, therefore, more than 75 volts difference of E. M. F. In order to use as fine a wire for this extra resistance as possible and thus diminish bulk and weight, the extra resistance coil is clamped between two aluminium plates made part of the lid of the instrument, as shown in Fig. 5, a pair of small flexible leads connecting it with the working wire. Another form of this instrument has been designed for laboratory use and for those engineers who prefer an instrument without a hinged lid. In this form the extra resistance is contained in a metal box located between the binding posts and contact key. By means of a switch a portion of the resistance may be cut out and a reading thus obtained for any desired fraction of the indicated voltage, the instrument lending itself readily to this "double scale" arrangement.

Instruments of the form illustrated are not adapted for higher E. M. Fs. than 600 volts, owing to the impossibility of securing in such small compass sufficient insulation and heat radiating surface for greater potentials. Accordingly a separate series of boxes has been designed to contain the extra resistance when high range instruments are desired and the scale of the instrument is made to indicate the E. M. F. actually at its own terminals. When the separate extra resistance is put in series with the instrument, then scale readings must be multiplied by some factor, depending, of course, upon the amount of multiplying resistance used.

A special plug has been devised equally applicable to the Edison, Thomson-Houston or Westinghouse sockets, so that the Acme instruments can be readily connected to incandescent lamp circuits for resting purposes.

Referring again to Fig. 1, the pointer carries a dasher which moves in an air chamber or dash pot, *A*. This makes the instrument extremely dead beat in its action, the pointer not swinging more than a small fraction of an inch beyond its proper position even when the maximum potential is thrown on. Consequently, accurate readings can be taken on railway and other circuits where the voltage changes rapidly. The extreme sensibility of the instrument to the most minute changes of current is obtained partly by the use of the very fine working wire (0.0012 inch in diameter, as previously mentioned), thus causing the temperature of the wire to change instantly for a change of current and partly by the great care taken to secure accurately pointed and polished pivots and correctly shaped and constructed bearings. These bearings are of selected sapphire cut to a carefully determined curve and very highly polished. In the "Acme" instruments the strains upon the working wire are extremely small as compared with the strains which the instrument can stand. Thus, the entire movable system, including, of course, the dasher, weighs but 6.25 grains, being made of hard drawn or rolled aluminium. The tensile strain produced in the wire by the take-up spring *T* is only 15 grammes at a maximum, whereas a tensile strain of 120 grammes is required to break the wire.

Owing principally to the fact that the elasticity of the take-up spring *T* of Fig. 1 changes necessarily with changes of the temperature, the instrument has a temperature correction. This correction is exceedingly small, and is not a percentage correction, but a constant for each instrument; approximately 2-10 volt for each 5° Fahrenheit in a 100-vo't instrument and correspondingly greater or less in higher or lower range instruments. This constant must be added to the readings for a rise of temperature and substracted for a fall of temperature. A thermometer graduated from 30° to 100° Fahrenheit is placed above the contact key, as shown in Fig. 5, so that this correction can be quickly applied. As to accuracy, it is claimed by the makers that results can be obtained with this instrument well within 1-4 of 1 per cent. on either direct or alternating currents of any frequency, and this, on alternating circuits, much more quickly than with any other instrument known. No difference can be detected reading up or down the scale, nor is the voltmeter

An Automatic Electric Light Switch.

The Sechrist automatic switch we illustrate, manufactured for the Central Electric Company, Chicago, is especially adapted for controlling incandescent lights in private residences. In that capacity alone it gives a great range of possibilities for convenience and comfort, besides being adapted for a number of other uses, among which are the controlling of electric bells, lights for railway signaling, etc. By means of this device a person may have absolute control of any or all of the lights in the house from any part of the house. A person in moving about a house in any direction, by means of

it, is always able to turn on the light ahead and at the same time turn off the lights from that part of the house which he has just left. Coming home at night, he presses a button outside, which turns on the porch light, enabling him to readily unlock the front door. Immediately on opening the door, the hall, parlor, library or dining room lights may be turned on or off, and the system can in the same manner be indefinitely extended.

The mechanism of the switch is shown in Fig. 1, being simply a locking and releasing device, operated by means of two electromagnets and enclosed by a neat case, not shown. There are no adjusting screws or complicated parts to get out of order. The electric circuit is attached to the switch the same as to any common switch, while the wires from the

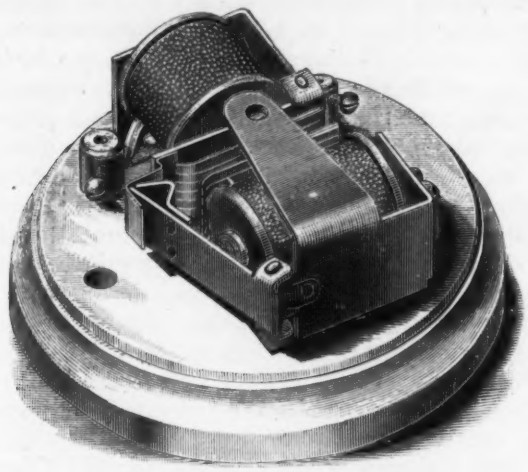


FIG. 1.—AUTOMATIC LIGHTING SWITCH.

magnet spools, which are common bell wires, run to the different push buttons from where the switch is to be controlled. The switch may be operated either by an ordinary battery or by means of the electric light current.

The method of running the wires and connecting them to the automatic switch may be readily understood by referring in Fig. 2, where *A* represents the back of switch; *B*, a group of lights controlled; *S*, an ordinary switch loop con-

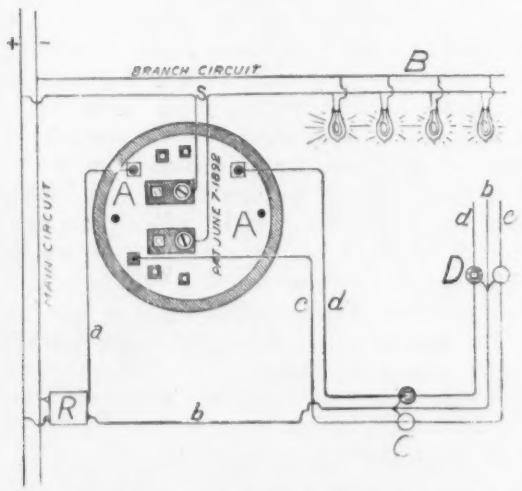


FIG. 2.—AUTOMATIC LIGHTING SWITCH.

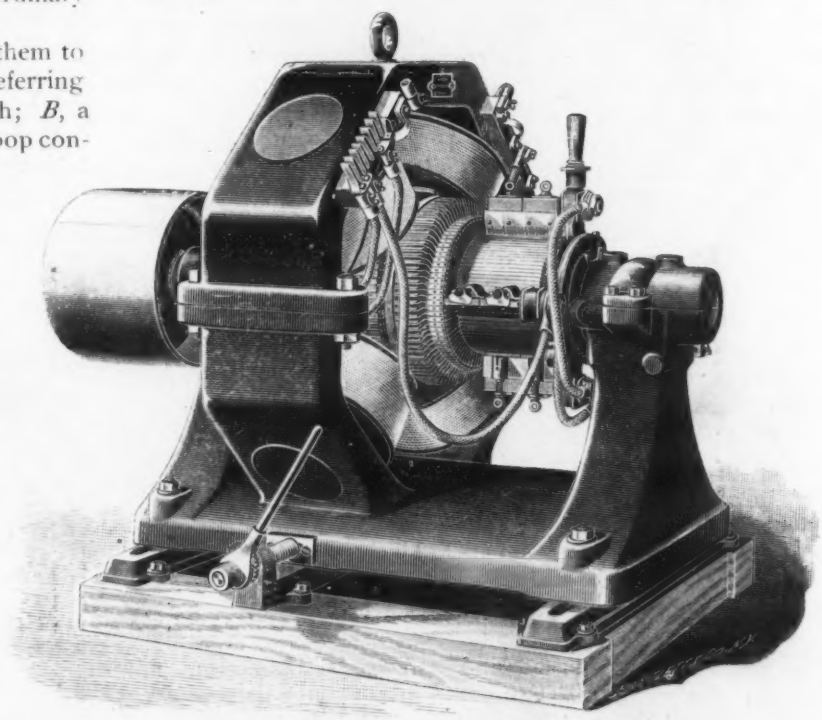
nected to the switch; *a b* are wires supplying the reduced current to operate the switch; *b, c, d* are ordinary bell wires, which run to the different push buttons from where it is desired to control the lights. *C D* are two sets of buttons similar to those used in electric gas lighting, and controlling the automatic switch *A A*. It is evident that any number of push buttons may be connected to the wires *b, c* and *d*. One resistance box for reducing the strength of the electric light current operating the switch may be used to supply current for any number of automatic switches. To operate the switch by means of a battery instead of the electric light current, a battery is substituted in place of *R*.

Crocker-Wheeler Standard Multipolar Machines.

Since moving to their new works at Ampere, N. J., the Crocker-Wheeler Company has been very busy perfecting a line of larger sizes of dynamos and motors, and we have an opportunity of illustrating one of the first of these.

The detail of these motors and dynamos represents the work of their entire engineering staff the past year. As will be readily seen by the illustration, great care has been given to produce an artistic design, a solidity of construction and a close adjustment of proportions electrically within the machine.

In the multipolar type illustrated the steel magnets are turned to gauge and set into the yoke, the outer end of the holes for the fields being covered by a thin circular plate. The pillow block standards are cast in one piece with the base, and the armature is rendered accessible by removing the caps of the bearings and the upper half of the magnet frame, thus permitting of the armature being lifted vertically out of the bearings, when the upper half of the magnet frame is thus removed. The rocker arm is made in halves, held together by wing nuts, and travels upon a grooved ring attached to the pillow block standard, and slotted, the grooved ring being cut away through the upper side wide enough to permit the shaft to be lifted out. No solder is used in any part of these machines, and besides being built to stand 25 per cent. overload without undue heating, they will stand an altogether unusual degree of heating without injury.



IMPROVED MULTIPOLAR DYNAMO.

The multipolar types above 25 h. p. (20 kw.) for 110 volts have armature conductors of rectangular copper bars riveted together by means of strip copper and connectors in place of the ordinary wire windings. The armatures thus wound, although for multipolar machines, have but two circuits, and may therefore be operated with one set of brushes instead of two sets, because of the novel cross connections within the armature. The common practice in multipolar armature

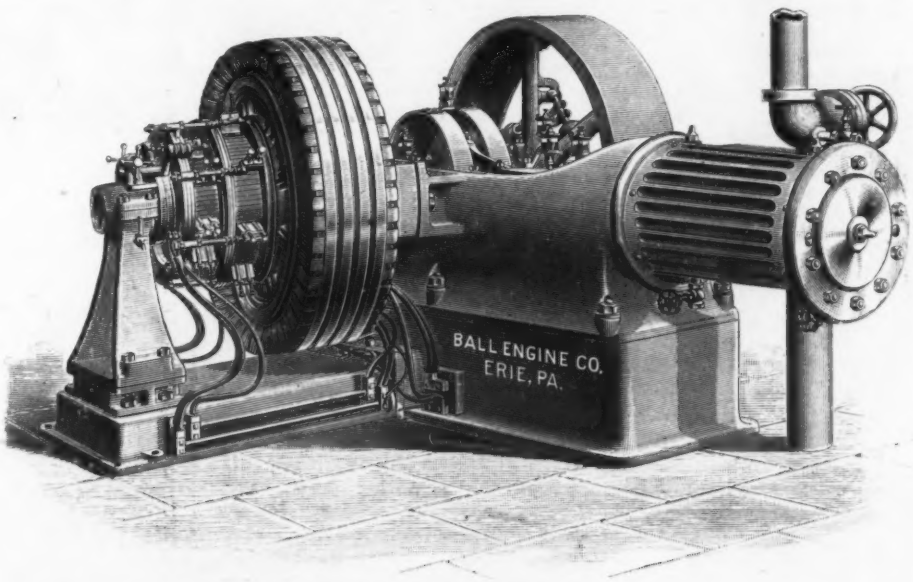
winding heretofore employed renders one portion of the armature liable to short circuit the other portions if there is any inequality in the strength of the fields. This construction is an improved form on that formerly followed by the Standard Electric Company, of St. Johnsbury, Vt., of whom the Crocker-Wheeler Company is the successor in this business. This form of armature was the invention of Mr. C. S. Bradley, and was the prototype of all of the bar wound armatures now commonly made in large sizes, such as for railway generators, etc.

In the new line of standard machines being brought out by this company, besides a high efficiency, the necessary losses are evenly distributed in the various parts of the machine, so that the heat produced by these losses may be evenly distributed, and thus permit the machines to stand the greatest abuse without any one part suffering in excess. We may add as a hint that this point of distribution of the efficiency losses seems to be the direction in which to look for improvement, and is a matter about which engineers of the company are very wide awake. For the equipment of the modern industrial power plants this higher class of apparatus is particularly appreciated. One plant furnished by the Crocker-Wheeler Company already amounts to about 500 h. p. in motors alone, to which additions are being frequently made.

Direct-Connected Engines.

The progress toward ultimate perfection of electrical machinery is manifested in many ways, but in no way more clearly than in the present use of engines directly connected to dynamos. This arrangement of engine and dynamo has a two-fold advantage. The first of these is the small floor space occupied. This is an important consideration for central stations, hotels and office buildings in large cities, where there is a steadily increasing demand for economy in this direction. Another advantage is in the elimination of wastes of energy by transmission through belts and counter-shafting. With the direct connected engine the frictional losses due to outside causes entirely disappear, leaving nothing but the internal friction of the engine to be accounted for.

The accompanying illustration represents an 80-h. p. Ball engine, directly connected to a Waddell-Entz dynamo. It shows the armature mounted on the engine crank shaft, which is supported on the end by an out-board bearing resting on an extended sub-base. This is a remarkably compact, durable and efficient arrangement, and has given the greatest satisfaction in practice.

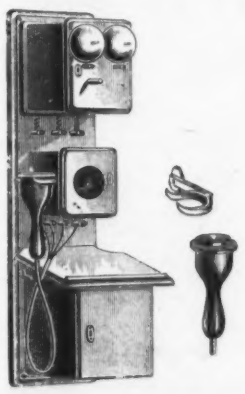


DIRECT-CONNECTED ENGINE.

The distinctive features of this well-known engine are beauty of design, simplicity and compactness, solidity and strength of frame, large bearings and wearing surfaces, excellence of materials and workmanship. The engine, therefore, is economical and durable, and being perfectly balanced, will run quietly and smoothly under the heaviest and widest varying loads. The regulation is so perfect that the engine will not vary to exceed 1 per cent. in speed. Every detail of construction receives the most careful inspection, and every engine is thoroughly tested before shipment is made.

New Telephonic Apparatus.

Among the various telephones now offered the public, we illustrate in this issue one based on a unique principle, constructed under patents which have been granted to Mr. S. D. McKelvey, Canton, Ohio. The general appearance of this telephone is the same as the well-known form now in use, which form, however, will be modified for the purpose it is intended to be used. The illustration herewith shows a telephone intended for exchange purposes and for private lines. Mr. McKelvey has also secured letters patent on a system designed especially for use in factories, stores, hotels and other large buildings, which is so arranged that any sub-station may communicate with any other sub-station without employing a central office, and is also the patentee of an effective auxiliary telephone, which is designed to be used in connection with sub-stations. The auxiliary consists of a specially constructed chair; the back of the chair is so made that it will act as a transmitter, so that a conversation may be carried on with perfect ease while the operator is seated in the chair. The principle on which this patent operates is the vibrations produced in the body of the speaker, which are transmitted to the chair back, and thence over the line in the usual manner. This chair telephone is so designed that the chair will answer the purpose of an ordinary office chair. Mr. McKelvey is now making experiments with a view of putting this attachment to any ordinary chair now in use. In devising this telephone Mr. McKelvey has departed from the usual paths followed by inventors, and has proceeded along new lines, employing a bipole non-metallic diaphragm in the receiver, a compound induction coil, the tertiary coil of which is connected in series, and an amplifying magnet located immediately behind the diaphragm in the transmitter. This telephone has been successfully worked over 115 miles of telegraph wire with earth return, and it is believed that when further experiments are made that a distance much greater than this can be successfully worked.

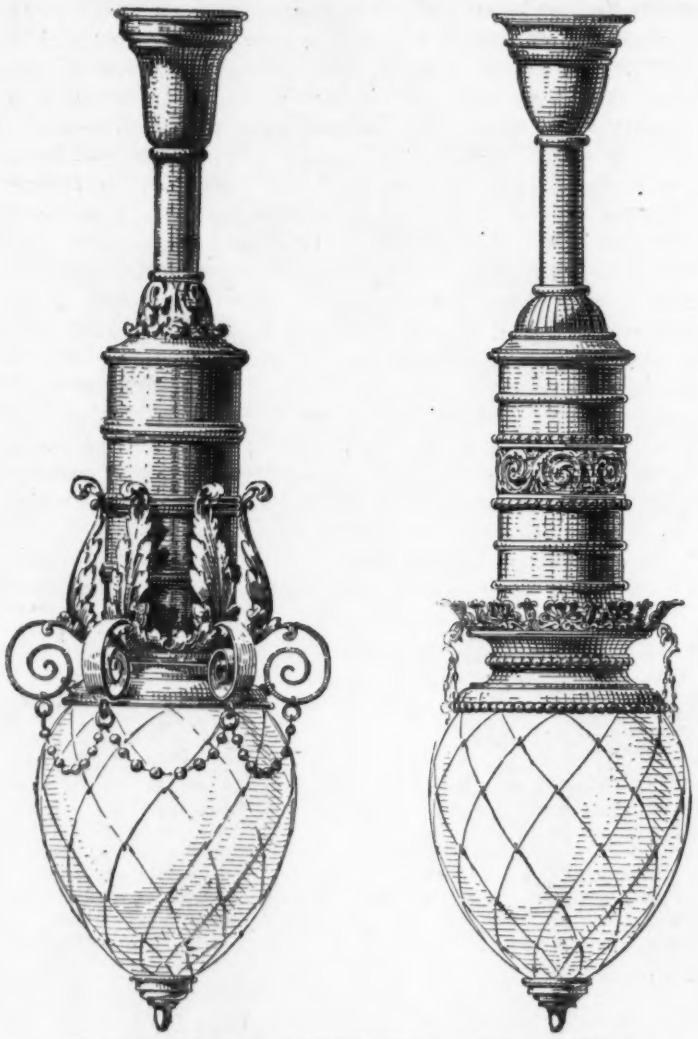


A NEW TELEPHONE.

Among the various other telephonic apparatus brought out by Mr. McKelvey is a dry battery for telephone and open circuit work, and which has been tested in all the various open circuits with the most satisfactory results. These batteries have been in use on an experimental telephone line constructed by Mr. McKelvey for the past eighteen months, and are giving the same satisfactory results to-day that they did when the line was first constructed.

A New Alternating Current Arc Lamp.

During the past year electric lighting by means of arc lamps on alternating current circuits has made marked progress, and the General Incandescent Arc Light Company, 572-578 First avenue, New York City, has recognized this fact by

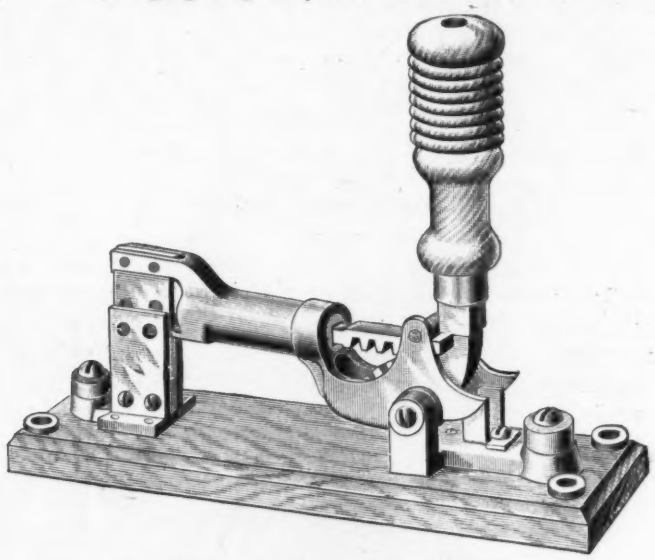


ORNAMENTAL ALTERNATING ARC LAMPS.

placing upon the market a new alternating current incandescent arc lamp of the same high standard of workmanship which has characterized its continuous current lamps. The company manufactures this new lamp in various styles and degrees of ornamentation from the plainest "standard" lamp of simple and neat design to the most elaborate creation of the metal worker's art. The accompanying illustrations give some idea of the attractive form in which these lamps have been gotten up. The General Incandescent Arc Light Company, however, does not rest its claims upon external appearance, but the operation of the lamp itself is said to be equal, if not superior, to the company's direct current lamp, which has attained such success. The lamps burn steadily, give as pleasing a light as the direct current lamp, and have given excellent satisfaction. Simplicity of mechanism, first-class workmanship, absolute steadiness without adjustment, ease of trimming, protection from dust and weather, starting at less than the normal current, no waste of current in resistance, large range of candle power and improved carbon holders are some of the claims for superiority which are made for this lamp.

Pneumatic Quick Break Switch.

The accompanying illustration of the pneumatic quick break switch, manufactured by the Ohio Brass Company, Mansfield, Ohio, shows it in normal position, when the circuit is closed. The action of the switch when opening the circuit is as follows: On drawing down the handle, a toothed segment engages with the rack shown on the end of the plunger rod, carries the plunger from the front to the rear end of the cylinder and compressing a coiled spring on the inside of it until the small projecting pieces on the movable arm strike against the shoulders on the body of the switch. The contact lips are then separated and the movable arm is drawn upward by the force of the compressed cylinder spring, giving a quick, wide break. At the moment the separation is made a jet of air is thrown against the arc, if any is formed, by the forward movement of the plunger in the cylinder, making it impossible for the current to carry over. The metal parts of this switch are made of polished brass, mounted on a slate base. They are made in single, double and triple pole types, ranging in capacity from 100 amperes upward. The contact lips are separable and reversible.



PNEUMATIC QUICK BREAK SWITCH.

New Book.

ENGLISH METHODS OF STREET RAILWAY TRACK CONSTRUCTION. By James More and Alexander McCallum. New York: Street Railway Publishing Company. 26 pages, 10 illustrations. Price, 35 cents.

This is a small pamphlet reprinted from the columns of the "Street Railway Journal," and, as indicated by the title, is on the methods of street railway track construction as carried out in Great Britain. The authors claim that in many respects English construction is superior to American, but aside from this claim, much information can be obtained from the pamphlet that will be of value to American street railway engineers.

Not Honest—On Sundays.

The editor of our bright London contemporary, "Lightning," calls attention to the fact that on Sundays the penny-in-the-slot cigarette machines will receive and keep the pennies but will not give any cigarettes in return.

Financial Intelligence.

The Electrical Stock Market.

NEW YORK, Feb. 23, 1894.

THE ELECTRICAL STOCK MARKET has made further progress towards higher quotations. In this it is but reflecting the improved condition of business, a feeling that all commercial circuits are participating in.

GENERAL ELECTRIC has been unusually strong this week. There has been any amount of bull talk on the property. It has been well known that the short interest existing for some time has been very apprehensive of late, and there is good ground for believing that a good deal of it has been scared to cover this week. There are semi-official reports that the company has paid off its floating debt, that it has numerous orders on hand, which, without any new business, is sufficient to pay the fixed charges and the preferred stock dividend and leave a 4 per cent. surplus applicable to dividends on the common stock. The Drexel-Morgan people still put in a good word for the stock, and there are indications of inside buying. The officials say the volume of business this year will be about $20,000,000, and the dividend on the preferred stock will undoubtedly be resumed at the end of the current quarter. There is no prospect, however, of an early recuperation of dividends on the common stock. The best thing has been the strong demand for the bonds; the 5s closed to-day at 80¼, a rise of about 5 points for the week.

WESTINGHOUSE ELECTRIC issues continue strong. From Pittsburgh comes the report that the company will at once become a very active competitor in the direct current arc light business. The company has perfected, it is said, a generator which has very great advantages over any of the forms now in use. Its efficiency is said to be some 10 per cent. higher than the average of generators now sold. The Westinghouse company intends to establish rates for this arc lighting apparatus on a purely commercial basis, so it will, therefore, be hereafter one of the most active competitors for a class of business heretofore almost exclusively enjoyed by the General Electric Company and its allied concerns.

THE POSTAL TELEGRAPH COMPANY and the American Bell Telephone Company will, according to a just published report, enter into a deal to consolidate their interests. The proposed increase of capital by the Bell company is supposed to have a bearing on the matter. The Postal company is understood to be earning a dividend now. No details of the proposed merger are known, but it will be a combination of vast importance.

WESTERN UNION TELEGRAPH has shared in the week's strength. It continues to command inside support, and the smaller shorts have become very uneasy over the scarcity of the stock in the loan market. The Goulds are openly bullish on all their properties and Western Union will be taken care of with the rest.

THE STREET RAILWAY AND ILLUMINATING PROPERTIES' trustees invite proposals for the sale to them of another $110,000 of the outstanding preferred stock. The $70,000 previously called has been cancelled, the average price being $82.90 per share. The range of stock accepted under the first call was about 80 to 84. There were tenders as high as 110, the maximum price at which it can be purchased for cancellation. Bids of 10 are made for the common stock, one small sale at 10½ being reported.

THE BELL TELEPHONE COMPANY of Canada reports for the year ending Dec. 31, 1893, gross earnings of $961,174, operating expenses of $236,383 and net earnings of $724,791. The paid up capital is only $2,421,000, so that the net earnings equal about 30 per cent. on the capital.

THE ELECTRIC ILLUMINATING AND POWER COMPANY, of Long Island City, has been incorporated at Albany with a capital of $50,000. The directors are H. H. Hollister, E. A. Maher, R. T. McCabe, John Stewart, Cord Meyer, Charles Hoffman and D. H. Valentine, of Brooklyn.

THE COMMERCIAL CABLE COMPANY'S new cable between Nova Scotia and Ireland will be commenced May 1; it will be 2,200 miles long. The stock is now quoted at 145 asked.

THE ALLENTOWN ELECTRIC RAILWAY, it is reported, has been sold for $300,000 by the Industrial Improvement Company, of Boston, to the Johnstown Company, of Allentown.

ELECTRICAL STOCKS.

	Par.	Bid.	Asked.
Brush Ill., New York	50	20	35
Detroit Electrical Works	10	2	3
Cleveland General Electric Co	—	85	90
East River Electric Light	100	—	65
Electric Con. & Supply Co., pref	15	15	16
" " " " com	15	15	17½
Edison Electric Ill., New York	100	96	98
" " " 1sts	—	105⅝	105¾
Edison Electric Ill., Brooklyn	100	99	102
" " " Boston	100	112	115
" " " Chicago	100	145	150
" " " Philadelphia	100	115	120
Edison Electric Light of Europe	—	—	3
" Bonds	—	80	85
" Ore Milling	—	5	12
Fort Wayne Electric	—	4⅓	6½
General Electric Company	100	38¼	38½
" " " deb. 5's	—	80	80½
Interior Conduit and Ins. Co	100	20	30
Mount Morris Electric	—	—	65
Westinghouse Consolidated	50	45	47
" " " pref.	50	26½	27½
Western Union Telegraph	—	83¾	84

New Incorporations.

THE AMERICAN ELECTRIC BATTERY COMPANY, Des Moines, Iowa, capital stock $250,000, has been formed to manufacture all kinds of electrical machinery, appliances and supplies. F. D. Goode, J. B. Cann, F. G. Curtis, H. B. Church and L. W. Goode are interested.

THE MADISON MILLING COMPANY, Madison, Minn., capital stock $50,000, has been formed to own and operate a mill and to furnish power for electric light and waterworks in that village. E. O. Berg, J. F. Jacobson, G. Herriges, N. Herriges and P. G. Jacobson, all of Madison, are interested.

THE PALMYRA ELECTRIC LIGHT AND POWER COMPANY, Palmyra, N. Y., capital stock $10,000, has been formed to do electric lighting, heating and to supply power. W. J. Morrison, Syracuse, N. Y.; B. H. Davis and S. P. Nichols, Palmyra, N. Y., are interested.

THE WAUKEGAN ELECTRIC RAILWAY COMPANY, capital stock $500,000, has been formed to construct, purchase and operate street railways, electric light, power and gas plants; also waterworks. M. C. Van Fleet, B. L. Jones and C. W. Plamer are the promoters.

Special Correspondence.

New York Notes.

OFFICE OF THE ELECTRICAL WORLD,
41 Park Row, NEW YORK, Feb 23 1894.

CAPTAIN WILLARD L. CANDEE AND GEORGE T. MANSON will, as usual; be on hand at the convention to represent the Okonite Company, Ltd. The popularity of these gentlemen is only equalled by that of the Okonite specialties themselves.

THE GENERAL INCANDESCENT ARC LIGHT COMPANY, 572-578 First avenue, New York city, will be represented at the Convention by its general sales agent, Mr. S. A. Douglas, who will explain the details and show the excellent points of the new incandescent arc lamps which the company has just placed upon the market.

E. F. GENNERT, who has been connected with the E. P. Gleason Manufacturing Company for nearly 22 years as superintendent and vice president, severed his connection Jan. 1 with this firm and is now general manager of the William Lang Company, manufacturers of metal goods, 123-139 Middleton street, Brooklyn, N. Y., which is contemplating going into the electrical supply business.

W. D. HOLMES AND GEORGE W. WALKER, manufacturers' agents, 136 Liberty street, New York, are placing on the market a new and novel electric shade which is light, durable and cheap. The shade is made of celluloid and has a fixture attached which will be suitable for any socket, and they are in all colors, from a dark bottle green to a plain white, are unbreakable and can be washed the same as porcelain. A cheaper shade is made of paper, which will be in great demand for central station and factory work.

THE COMPLETE ELECTRIC CONSTRUCTION COMPANY, of 121 Liberty street, New York, recently closed contracts for the following: With the Brush Electric Company, of Philadelphia, for a 10-mile subway, and with the Lakeside Railway Company for a complete electric railway from Mahanoy City to Shenandoah, Pa., to consist of a Westinghouse equipment with 260-h. p. generator and engine, and 70-T. R. bracket construction. Mr. J. A. Seeley is the president of the company and C. O. Baker, Jr., secretary and treasurer.

CUTTING DOWN WIRES.—The work of cutting down overhead wires is proceeding under the direction of Chief Inspector Brown, of the Board of Electrical Control. The start was made on the roof of the Fifth Avenue Hotel, and the men will work down as far as Twelfth street at once. The district is between Fourth and Sixth avenues. Mr. Brown said that he would leave a few wires overhead, belonging to people who have permits from the Board of Electrical Control, and added that the work will be the most extensive of its kind ever undertaken in this city. The work of cutting the wires will be continued until the men reach the Battery.

MR. THOMAS C. PERKINS, vice president of the Mather Electric Company, Manchester, Conn., was in the city last week and reported plenty of business, with bright prospects for the future. The Mather company, having been thoroughly reorganized, is now better than ever equipped for the line of work for which it has long been well known. It also intends to pay special attention to constructing railway generators. The company proposes in the future to deal directly with contractors as agents in various parts of the country, instead of establishing numerous local branches or offices. G. M. Anger, 116 Bedford street, Boston, Mass., is the contractor for the Mather apparatus in New England.

English Notes.

(From our own Correspondent.)

London, Feb. 14, 1894.

TRAMWAY STATISTICS.—The latest Board of Trade returns show that whilst in Scotland the net earnings are on the average £1,100 per mile, the same figure for England and Ireland is respectively £800 and £600. The municipalization of the tramways, as well as the electric light, is proceeding apace, but has not as yet attained very large dimensions. Only three local authorities, viz., of Blackpool, Huddersfield and Plymouth, are at the present moment actually working their tramways. Of the total tramways in the United Kingdom one-fourth are owned by local authorities, and it is interesting to note that whilst the average total expenditure per mile in the case of the municipally constructed lines amounts to a little over £11,000, the same figure for the lines constructed by private enterprise aggregates £16,000, the average for the United Kingdom being about £15,000.

TELEGRAPHIC COMMUNICATION BETWEEN INDIA AND ENGLAND.—Mr. E. O. Walker, late of the Indian telegraph service, will read to-morrow an interesting paper at the Imperial Institute on the subject of the present condition and future prospects of telegraphic communication between England and India. The most important points brought out by Mr. Walker are: (1) That the time has now arrived when, in the interest of the commercial community, the present 4s. word tariff should be gradually reduced to 1s. (2) That the present prosperous financial condition of the telegraph companies concerned permits of their gradually reducing their tariff without much danger of a diminished return to their shareholders. (3) That whilst the early land lines across Turkey, Prussia, Russia, etc., were constantly interrupted, experience has taught us how to obtain from them almost as regular a service as from submarine cables. (4) That failing reasonable reduction in tariffs on the part of the companies, the Indian Government would do well to run a line on its own account from the Indian frontiers across Afghanistan, Persia, the Merv, Russia and Prussia to the North Sea, and then by cable to England.

THE LAMP CONNECTIONS OF THE METROPOLITAN ELECTRIC LIGHT COMPANIES.—Whenever the rapid increase in the lamp connections of our metropolitan electric light companies is brought to the notice of the gas interest, the gas journals almost invariably console themselves by prophesying that the present rate of increase will not be kept up very much longer. However that may be, if one goes to the trouble of plotting the (lampage) curves, it cannot be said that those relating to the leading and largest companies show any signs of saturation. For instance, the Kensington and Knightsbridge company has increased its lamp connections during the past twelve months by 35 per cent., and has just paid a dividend to its ordinary shareholders of 5 per cent.

News of the Week.

Electric Light and Power.

LEADVILLE, COL., has organized a second electric lighting company.

LYNCHBURG, VA.—Lynchburg is to have its own electric lighting plant.

HAMILTON, OHIO.—Bids for the proposed electric lighting plant will be received by Council till March 17.

ONTONAGON, MICH.—The city will vote March 12 on an issue of $30,000 in bonds for electric light and waterworks.

WHITEHALL, N. Y.—T. S. McLaghlin will incorporate an electric company to take over his electric lighting plant.

WASHINGTON, N. J.—Rutherford Stuyvesant will build another electric lighting plant on the Tranquility farms.

CONNERSVILLE, WIS.—F. T. Roots is corresponding in the matter of changing from his present water power to electricity.

HOUGHTON, MICH.—The Peninsula Electric Light Company will duplicate its plant at Houghton during the coming summer.

VICTORIA, TEX.—Jas. Koyer has bought a controlling interest in the electric lighting plant, and will make many improvements.

SPRINGFIELD, ILL.—The City Council committee on lighting has decided to reject the propositions of the gas and electric light companies.

PROVIDENCE, R. I.—Mr. John J. Moore has succeeded Mr. Marsden Perry as superintendent of the Narragansett Electric Light Company.

WILMINGTON, N. C.—Sealed proposals will be received till March 16 for lighting the city with electric lights. S. H. Fishblate is mayor.

YORK, PA.—The ordinance authorizing an appropriation of $40,000 for an electric lighting plant was reported negatively from the ways and means committee.

ENFIELD, CONN.—The Enfield Electric Light and Power Company will extend its plant as far as the First Congregational Church, and will wire same for electric lighting.

SANDWICH, ILL.—At a Council meeting the bids for the steam portion of the electric lighting plant were rejected, and the specifications will be revised and resubmitted for bids.

THE HOME ELECTRIC COMPANY, of Tyrone, Pa., has just added a large boiler to its plant, and also a new switchboard designed by the superintendent, Mr. S. H. Stauffer.

SAN DIEGO, CAL.—Sealed proposals will be received to March 22 for lighting the streets and parks with electricity for one year from the 1st of April, 1894. S. W. Belding will give details.

NIAGARA FALLS, N. Y.—The Niagara Falls Electric Light Company is making arrangements to extend its wires and build a new plant, likely to be located near the old Wesley Park.

WOODSTOWN, N. J.—A strong effort is being made to establish an electric lighting plant in Woodstown. It is proposed first to light the business places in the middle of the city and then the entire city.

PORTLAND, ME.—C. B. Dalton offers for sale or lease two water powers of 5,000 and 2,500 h. p., respectively, and 18 and 20 miles distant from Portland, Me. Mr. Dalton calls attention to the fact that the city pays $38,000 per year for lighting the streets alone.

MONTCLAIR, N. J.—Paul Wilcox and other local capitalists applied to the township committee of Montclair, N. J., for an electric lighting franchise. The application was referred to the street lighting committee, of which M. N. Baker is chairman. From 500 to 800 incandescent lamps would be required to cover the town.

The Electric Railway.

SOUTH NORWALK, CONN.—The tramway company proposes to extend to Roton Point and Five Mile River.

GAYSPORT, PA.—The Logan Valley Electric Company has been granted right of way through Gaysport.

ROCKVILLE, MD.—The extension of the Bethesda Electric Railroad Company to Rockville is being agitated.

ENGLEWOOD, N. J.—Judge Phelps is said to be interested in a proposed trolley line between Englewood and Hackensack.

MIDDLETOWN, PA.—The Hon. J. W. Rife has been refused an extension of time in which to begin work on his proposed electric railway.

YOUNGSTOWN, OHIO.— Bids will be received to March 3 for operation of an electric street railway. J. Howard Edwards is city clerk.

ASHLAND, WIS.—The Ashland Lighting and Street Railway Company will issue $250,000 in bonds to pay off indebtedness and make improvements.

ANN ARBOR, MICH.—The Ann Arbor Electric Street Car Company and the Ypsilanti motor line have decided to consolidate and run the whole line by electricity.

HOLYOKE, MASS.—The Board of Aldermen of Holyoke will give a hearing March 6, at 8 P. M., on the petition of the Holyoke Street Railway Company for leave to extend its lines.

WARREN, OHIO.—A corporation with $10,000 capital has been organized to construct a railroad between Kinsman and Farmdale. D. N. Yeomans, E. R. Brackin and J. A. Russell are interested.

PHILADELPHIA, PA.—The Philadelphia "Record" states that property on Delaware avenue, near Laurel street, has been purchased as a site for a mammoth power house for the Electric Traction Company.

PHILADELPHIA, PA.—The contract to build the trolley road of the Lehigh Traction Company from Harleigh to Freeland, seven miles, has been awarded to the Westlake Electric Company, of Philadelphia.

HORNELLSVILLE, N. Y.—Residents of Howard, about eight miles from Hornellsville, are agitating for an electric railway to connect the town with Hornellsville or Canisteo, to be used for both passengers and freight.

GAITHERSBURG, MD.—Upton Darby, president of the bank, is corresponding with northern capitalists with a view to constructing an electric railway from the intersection of Seneca with the Potomac River to Gaithersburg.

ELKHART, IND.—The Elkhart electric railway has been sold to O. N. Lumbert for $24,000. An effort will be made to consolidate with the Goshen railway, and work will soon be commenced to complete the line between the two cities.

KINSMAN, OHIO.—The Kinsman-Farmdale Electric Railway Company is incorporated, with a capital of $10,000, to build a street railway to connect the towns of Kinsman and Farmdale. D. M. Yeoman, E. R. Brackman and J. A. Russell are interested.

STAMFORD, ONT., CANADA.—Two applications for electric railway franchises have been received by the Stamford Council, one from Mr. Black and another from B. Lundy, in connection with E. A. C. Pew. Both applications were placed on file.

TOWANDA, PA.—A project is being pushed to connect Towanda and Wellsboro, by way of Troy, Sylvania and Mansfield, by an electric railroad. Most of the right of way from Troy to Mansfield has been obtained. Charles Card, of Sylvania, is interested.

NIAGARA FALLS, N. Y.—Burt Van Horn, Jr., representing the Niagara Whirlpool and Northern Railroad Company, has given notice that he will apply for a franchise for an electric road on Main and other streets, and Common Council will pass upon same March 5.

LA CROSSE, WIS.—The La Crosse and Oskaloosa Street Railway Company will increase its capital from $30,000 to $50,000, and will equip its line with electricity. Work will be begun as soon as the weather permits. J. B. Canterbury is president, and E. B. McGill is secretary.

KINGSTON, N. Y.—The Kingston "Leader" states that the company which proposes to build an electric line between Kingston and Ellenville will be called the Rondout Valley Electric Railway Company, and that it will light the villages through which it passes by electricity.

DIXON, ILL.—The Rock River Electric Railway Company has been incorporated and will extend via Grand Detour, Oregon and Byron to Rockford. The president of the new company, James H. Ticknor, of Rockford, has already over ten miles of electric railway in the city of Rockford.

STOWE, VT.—The Mount Mansfield Electric Railway Company has been incorporated, with a capital of $50,000, to build an electric road from Stowe to Waterbury, a distance of ten miles. E. D. Blackwell, of Montpelier; O. E. Luce, of Stowe, and L. A. Pike and L. C. Moody, of Stowe, are directors and will give details.

ELIZABETH, N. J.—Articles of incorporation of the Suburban Railway and Electric Company, $750,000, were filed in the office of the county clerk in Elizabeth, and its principal office will be here. The incorporators are James B. McGiffert, of Roselle; W. B. Hosmer, of Boston; John S. Bartlett and Charles H. Newhall, of Lynn, Mass.

HOMESTEAD, PA.—The Homestead Borough Council has granted right of way to four companies to operate electric roads in their streets—the Homestead and Highland Railway Company, the Pittsburg and Homestead Railway Company, the Homestead Street Railway Company and the Second Avenue Railway Company.

BURLINGTON, VT.—The proposed electric road from Burlington is now assured. Hon. Isaiah Dow, C. G. Peck, Albert Reed Ray, Perry Reed and H. M. Hull, of Hinesburg, and C. W. Brownell and Frank O. Sinclair, of Burlington, are interested. The latter is engineer for the project. C. G. Peck, of Hinesburg, will shortly address a mass meeting.

SCHUYLERVILLE, N. Y.—Dennis B. Hill, of Greenwich, N. Y., has obtained permission from the commissioners of the town of Saratoga to erect poles and string wires along the highway leading from Northumberland through Schuylerville and Grangeville to Saratoga Springs. It is the object of Mr. Hill to furnish power from the plant now being installed at Clark's Mills for an electric railway.

NORFOLK, VA.—A bill was introduced at Richmond to incorporate the South Norfolk Street Railway Company, and it was opposed by the existing street railway officials, who claim that they are just beginning to see financial daylight, and that there is not traffic enough for two roads, and, further, that they have made arrangements to extend their road and equip with electricity. Notwithstanding the protest, the bill was reported favorably.

PLAISTOW, N. H.—Residents have issued an ultimatum to the projectors of the New Hampshire electric railway system that if Plaistow is not included in the route they will oppose the scheme. It is stated that prominent residents of Plaistow are interested in the scheme to build an electric road from there through South Kingston, Kingston Plains and thence to Brentwood, and that plans have been drawn and the road will soon be incorporated.

ITHACA, N. Y.—The Cayuga Lake Electric Railroad Company has filed articles for incorporation, the principal office to be at Ithaca, N. Y., to operate an electric railway, length not to exceed two miles, and the capital stock to be $25,000. The names and addresses of the incorporators are Alfred Hand, Horace E. Hand and E. L. Fuller, of Scranton, Pa.; De F. Van Vleet, Herman Bergholtz and E. P. Fuller, of Ithaca, N. Y.; Charles W. Hand and Henry S. Hand, of Brooklyn, and Fred W. Spender, of Staten Island.

WASHINGTON, D. C.—On the calendar of the Senate District committee are the following railway bills: The Washington and Arlington Street Railway Company, W. H. Randle, J. S. Lawrence and Beriah Wilkins; the Washington and Benning Street Railway Company, introduced by Senator Gibson—Levi Woodbury, Caleb S. Willard, Robert Downing; the Washington Central Railway Company, John H. Knight, Henry H. Rand, Perry W. Boyd, Michael I. Weller and Nathaniel McKay; the Washington, Alexandria and Mount Vernon Company applies for right to use electricity as motive power.

Personal Notes.

THE NATIONAL ELECTRIC LIGHT ASSOCIATION is so intimately associated with the names of George F. Porter and and Cyrus O. Baker that its annual gatherings could hardly be counted a success if they were not present. Mr. Porter, the secretary of the association, has yet some time this side of the forties, having been born in Pittsburgh, Pa., on March 12, 1855, where his childhood was spent, and from whose public schools he graduated. In early life he practiced civil and mechanical engineering, later entering the iron business, in which he remained until 1883, with the exception of an excursion into the electrical and railroad field from 1875 to 1877. During Mr. Huntley's term as president of the National Electric Light Association Mr. Porter became its secretary, to which position he has been twice reappointed.

Mr. Baker, the master of transportation, has become such an indispensable adjunct to electric light gatherings that his absence on such occasions would be considered almost a calamity. Mr. Baker was born in Newark, N. J., on the 12th of October, 1857. For many years past he has been connected with the firm of Baker & Co., of Newark, who are the only refiners of crude platinum in America, and who, with Johnson, Mathey & Co., of England, are known the world over as the principal workers in this refractory metal. Besides his connection with this business, which has had such a close association with the electrical industries since the discovery of the incandescent lamp, Mr. Baker is financially interested in a number of electrical matters, including an electric lighting plant at Newtown, L. I., of which he is president and Mr. Porter is secretary and treasurer. He has presided over the transportation department since its foundation in 1886 and in a manner as efficient as his attention to his charges is genial.

Miscellaneous Notes.

THE FRANKLIN INSTITUTE has awarded, subject to objection, until April 1, the Elliott-Cresson medal to Nikola Tesla for his "Researches in High Frequency Phenomena."

THE CITIZEN'S TELEPHONE COMPANY, St. Joseph, Mo., will start a telephone exchange and has been very successful in its canvass for subscribers. Mr. M. M. Riggs is president.

BOSTON, MASS.—The Drawbaugh Telephone Company has petitioned for incorporation with a capital of not less than $1,000,000 nor more than $10,000,000. Fred O. Prince is at the head of the company.

PROF. F. B. CROCKER delivered a lecture on electric lighting at Cooper Institute on Feb. 14, being one of the course of University Extension lectures. While the lecture mainly dealt with the more elementary features of electric lighting, several points of importance were enlarged upon, as the candle power of arc and incandescent lamps and the economics of the latter.

THE ELECTRICAL ENGINEERING LABORATORY at Purdue University, Lafayette, Ind., we are informed, was not damaged in the recent disastrous fire which destroyed portions of the shops and the mechanical engineering laboratory. A large generator was lost in the fire, but with this exception the electrical equipment was uninjured, and the work in this line is progressing as usual.

ANOTHER PENNOCK.—An impostor named Fred. L. Schupp recently gulled some simpletons in Manayunk, Pa., to the extent of $1,000, through claims that an idiot should have suspected. By means of a device he exhibited, which could be placed in the woodwork of a door or house, he claimed that with a simple chemical battery he could light a house on the same principle "that electricity is utilized to ring door bells." A house was wired, a small "nickel-plated, clock-like machine" placed in the vestibule, and the stockholders asked to be present to witness the test. At the last moment Schupp disappeared, and it was discovered that he had meant to connect the house with a trolley wire passing the house, but was scared off by the discovery that he was being watched.

SOME THEORIES.—A recent pamphlet contains the following: "By decomposing zinc with an acid, its stored energy, its chemical affinity, is released and comes forth in the form of electricity. But suppose you try decomposing iron or steel with this acid, and its energy comes out in the form of heat, with no electricity about it. The reason zinc gives forth electricity is because of its extraordinary chemical constitution, which no other material possesses. To come right to the point, it is undoubtedly a fact that the mode of the atomical motion brought about by the decomposition of zinc is altogether different from that of other materials, and this mode of motion happens to be the same as that brought about in the coils of a dynamo by the magnets passing them. Heat is evidently a simple reciprocating atomical motion, while in the case of electricity we have the best of evidence by its manifestations, if not positive proof, that it consists in a rotary reciprocating motion of polarized atoms on an axis."

Trade and Industrial Notes

THE HOWARD SYSTEM of arc lighting will be presented to the N. E. L. A. Convention at Washington, D. C., by Mr. Charles R. Huntley, of the Buffalo General Electric Company. Mr. Huntley has made an exhaustive test of the system on his circuits in Buffalo.

THE BERLIN IRON BRIDGE COMPANY, of East Berlin, Conn., has furnished the iron roofs for the new electric light station for the Citizen's Electric Light, Heat and Power Company, at Lancaster, Pa., and the dye house of George C. Hetzel & Co., Chester, Pa.

JAMES LEFFEL & CO., Springfield, Ohio, direct the attention of electrical engineeers to their "Samson turbine" water wheel. This wheel is furnished in a number of styles on upright and horizontal shafts, and is specially designed and adapted for driving electric lighting and power plants.

C. B. DALTON, 7 Preble street, Portland, Me., offers for sale or lease two water powers of 5,000 and 2,500 h. p., and 18 and 20 miles, respectively, from Portland. That city is now paying $33,000 per year for street lighting alone, and the lowest price of steam horse power is quoted at $75 per year.

THE W. D. GRAVES ELECTRICAL AND MACHINE WORKS, Cleveland, Ohio, has issued a catalogue of the various arc-lighting apparatus manufactured by it, as well as of the Graves transformer. The Graves arc lamp received an award at the Chicago Fair, and continues to meet with success.

THE WESTON standard voltmeters and ammeters are theoretically correct in principle, accurate throughout their entire range, simple in construction and economical to operate. Their popularity is an established fact, and the Weston Electrical Instrument Company, of Newark, N. J., is a busy concern.

THE GOUBERT MANUFACTURING COMPANY, 32 Cortlandt street, New York City, manufactures two steam specialties well worthy of the careful investigation of every member of the National Electric Light Association. We refer to the Goubert feed water heater and Stratton steam separator, of both of which it is the sole manufacturer.

THE AMERICAN SILK MANUFACTURING COMPANY, manufacturer of silk wipers, Philadelphia, Pa., has just received a very flattering testimonial as to the merits of its wipers from Mr. J. A. Tarpley, chief engineer of the United Electric Railway Company, of Nashville, Tenn., in which he states that the wipers are the best he has ever tried.

MR. H. I. HADAWAY, who is well known throughout Kentucky, Indiana and Ohio from his long connection with George Cutter's specialty line, has opened an electrical supply house at 503 Third street, Louisville, Ky. He expects to carry an assortment of both electric light and house goods, and has the best wishes of a host of friends with him in this undertaking.

THE PARAGON PITCH COMPANY, Cleveland, Ohio, is making a new insulating pitch, which has proved very satisfactory in all tests so far made, several manufacturers already consuming large quantities of it. A representative of the company is expected to be at the convention, in Washington, when those interested will do well to examine into the merits of the new material.

THE AMERICAN RUBEROID AND RUBBER MANUFACTURING COMPANY, 206 Centre street, New York, has placed on the market a line of ruberoid tubing for electrical purposes, which has been approved by the New York Board of Underwriters. The tubing, while almost as hard as ordinary hard rubber tube, is flexible, and in large sizes can be bent to a right angle with a small radius.

THE WAKEFIELD ELECTRICAL ENGINEERING COMPANY, 731 Reading Terminal, Philadelphia, Pa., has secured a contract for a seven-mile extension of the Lehigh Traction Company, Hazleton, Pa. The road is to be built in a very substantial manner, and graded according to the best steam road practice, and will also include several large trestles. Work will be in charge of Mr. A. W. Gilbert, constructing engineer for the company.

THE ABENDROTH AND ROOT MANUFACTURING COMPANY, 28 Cliff street, New York City, reports a brisk demand for its Root improved water-tube steam boiler, with recent orders of 248 h. p. for Para (Brazil) Electric Light Company; 2,000 h. p. for tunnel plant of Baltimore and Ohio Railroad Company, at Baltimore, Md.; 4,000 h. p. for Cincinnati Street Railway Company, and two large boilers for the Flatbush Gas Company, Flatbush, L. I., N. Y.

MESSRS. D. L. BATES & CO., Dayton, Ohio, are meeting with flattering success with the Bates fan and motor, which is claimed to be indispensable to hotels, cafes, restaurants, etc., where a thoroughly reliable and ornamental fan motor is required. It runs with a minimum amount of cost and expenditure of energy. These fans can be run on any direct-current incandescent light or street railway circuit, and are made for 110, 220 and 500-volt circuits and also for 10-ampere arc circuits.

THE ELECTRIC LIGHT EQUIPMENT of the large addition to the Chicago post office has been made very complete in every respect, every cabinet and desk being equipped with the most effective kind of electric and combination fixtures. The contract for furnishing these fixtures has just been completed by the Electric Appliance Company. The contract was secured only after considerable competition, and the Electric Appliance Company feels considerably elated at their success.

THE BALL ENGINE COMPANY, of Erie, Pa., has made a number of installations of direct connected engines in connection with various types of dynamos; among late ones are two 200-h. p. cross compound engines, directly connected to Siemens & Halske dynamos in the Lumber Exchange Building, Minneapolis, Minn.; one 125-h. p. Simplex engine, in connection with Waddell-Entz dynamo, in the store building of Willoughby, Hill & Co., Chicago; one 80-h. p. engine in connection with Waddell-Entz dynamo, in the building of Cumner, Craig & Co., Boston, Mass.

THE TAYLOR BATTERY COMPANY has issued an illustrated catalogue, in which it claims that the Taylor battery has been perfected, and the statement verified by those who use it practically, as well as by scientific men. Among the new features we notice the following: Prepayment of freight, out of town customers furnished with formula of the depolarizer, a modification of the Minotto cell for all-summer work on fan motors, slow-speed motors for boats, motor castings, novelties in telephones and estimates for small electric lighting plants. The battery is renewed without disconnecting or removal of jars.

THE PAGE BELTING COMPANY, of Concord, N. H., at the present time is making three wide belts for the Suburban Electric Company, Elizabeth, N. J.; a 54-inch double for the Union Railway Company, New York, and for a large New England manufacturing concern a wide three-ply belt of construction similar to the large tandem belts which it exhibited at the World's Fair, running on the Allis engine. All these large belts are the famous "Crown" brand, for which it received at the Columbian Exposition "The Highest Award." As is well known, this company was enterprising enough to be the first to publish a copy of this award and a reproduction of the Columbian medal of award, as designed by St. Gaudens, which has created such a stir. Besides these orders it has recently shipped to Japan a very large order of single belting, the third received from that country since the first of the month.

THE WASHINGTON CARBON COMPANY, of Pittsburgh, Pa., has been at work for the last two years perfecting a cored carbon, and now announces that it will be ready to place the new carbon on the market about March 20. To Mr. L. B. Marks, well known not only for his work in the carbon line, but also in connection with the Howard system of arc lighting, is due the success in developing the new carbon. Mr. J. S. Humbird, the president of the Washington Carbon Company, says he believes that this carbon will give as good satisfaction as foreign makes, and he hopes even better. The company's selling agents in Boston, New York, Philadelphia, Chicago and St. Louis are now prepared to fill orders for the carbon.

THOMAS C. WARLEY & CO., 11 South Ninth street, Philadelphia, Pa., manufacturers of boilers cleansing compounds, have had a greater sale of their products during the months of November and December of the past year, and January of this year. This firm has been before American steam users for several years past, and now numbers amongst its customers some of the largest railway and lighting plants in this country and Canada. The universal satisfaction given by their compound, as a preventive and remover of scale, to the many who have used it commends it to those who have not availed themselves of its sterling qualities, and, as the item of boiler repairs is a very important one, the managers of power plants will be more than convinced of the merits of this article by investigating it. A representative will be at the electric light convention with a sample of the article manufactured, and proof of the work done.

Business Notice.

BATTERY CUT-OUT, CHEAP.—Sensitive, reliable, never requires attention. Gas lighting much improved by its use. Electric Supply Company, of 105 South Warren street, Syracuse, N. Y.